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DRSAR/SA/N-48

BILLET CRANE SIMULATION

GERALD L. MOELLER

AUGUST 1976

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US ARMY ARMAMENT COMMAND

SYSTEMS ANALYSIS DIRECTORATE

ROCK ISLAND, ILLINOIS 61201

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The purpose of this study is to develop and provide an analytical model which can be used to evaluate the capability of proposed alternative crane systems to perform the material handling task at the Scranton Army Ammunition Plant. The Logistics Division of the Systems Analysis Directorate developed a computerized model to evaluate the capability of a proposed new crane systems.

The conclusion was reached that the 200-ft-per minute top velocity crane should more than adequately be able to handle the proposed mobilization workload.

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INTRODUCTION

This study is in response to a request of the Commander, Scranton Army Ammunition Plant, to determine if a proposed replacement yard crane system can satisfactorily perform the material handling task. The overhead rails of the existing crane are becoming structurally inadequate. Upon studying the physical layout of the yard and the structural integrity of the soil and supporting columns of the present system, the Army Corps of Engineers has recommended tearing out the present system and replacing it with a much slower traveling gantry crane. Since a substantial amount of money is involved, the Commanding Officer at the Scranton Plant has requested the development of a prove-out computerized simulation model. In response to this request, the Logistics Division of the Systems Analysis Directorate developed a FORTRAN based computerized model described in the balance of this note.

PURPOSE

a. Develop and provide an analytical model which can be used to evaluate the capability of proposed alternative crane systems to perform the material handling task at the Scranton Army Ammunition Plant.

b. Determine if the new yard crane proposed by the Army Corps of Engineers can satisfactorily perform the material handling task at the Scranton Army Ammunition Plant.

METHODOLOGY

The FORTRAN program developed for this simulation model is event-oriented with the capability to take samples from the model at discrete uniform time intervals. There are two classes of events in this model: (1) independent events, those events the crane has no control over, and (2) dependent events, those events the crane creates in responding to the independent events. The independent events are as follows:

1. A charging call from Feeder or Line No. 1.

2. A charging call from Feeder or Line No. 2.

3. A charging call from Feeder or Line No. 3.

4. The arrival of a 5-1/4 inch heat.

5. The arrival of a 6 inch heat.

6. The arrival of a 7-3/8 inch heat.

7. The morning coffee break.

8. The lunch break.

9. The afternoon coffee break

10. The shift break.

Specific distributions have been derived for the length of time between repeated occurrences of the same event (see APPENDIX B).

The dependent events of preparing and loading charges into the feeders and unloading and stacking billets in open storage bays consisted of 7 basic tasks as follows:

1. Picking billets up.

2. Setting billets down.

3. Squaring billets up.

4. Swinging billets into position.

5. Breaking for coffee, lunch and shift turnover.

6. Traveling.

7. Idleness.

Specific time distributions for each of the first 5 tasks were derived for each of the unique operations in which these tasks occurred. The standard Newtonian Equations of Motion were employed to model the crane's travel. These equations were further supplied with data generated from acceleration, deceleration, and top velocity distributions. These distributions allowed for operator-to-operator speed variation. Break times were modeled as distributions; however, the management cautioned that these periods could be eliminated if a high level of impending activity warranted it. Idleness was the residual. If the crane had nothing to do, it was idle. (See APPENDIX B for a review of the previously described inputs.) These 7 basic crane tasks were monitored during the simulation to enable the crane's consumption of time to be reviewed.

The basic structure of this model consists of a 1 dimensional array which stores the next time each of the 10 independent events will occur, and a clock which is event-incremented. These events include all the independent events and the various tasks of the dependent events. Each time the clock is incremented after completing a dependent event, the next independent event is checked to see if it has occurred. If an independent event has occurred, it is processed and a new time is generated to determine when this event will next occur. If an independent event has not occurred, the program continues processing the crane's dependent events. If there are not any dependent events to process, the model advances to processing the next independent event.

ASSUMPTIONS

When constructing a mathematical model, some assumptions or ground rules must be formed to define a base for the study. Further, some assumptions must be made on noncritical entities to avoid creating more structure than is necessary to create a desired or adequate level of realism. A high level of resolution of noncritical activities cannot be economically justified. These assumptions (except the first one) can easily be altered within the computerized model. They are as follows:

1. Only one crane will be in operation at a time.

2. 100 percent reliability is required (at least one crane will be operable at all times).

3. The billets arrive in groups of cars carrying one heat rather than in individual cars strung out over an extended period of time, thus creating an intermixing of heats.

4. The heats will be unloaded in car segments with the cars being individually positioned with an offset from the center line of the receiving bay.

5. Billets are stored and charged or loaded into the feeders in heats which are assumed to be groups of about 175 billets each.

6. Bays are assigned usage priorities and a maximum load capacity for the given type of billet (5-1/4, 6, or 7-3/8 inches) which the bay can handle.

7. At least one charge for all three feeders will be ready at all times and will be residing in a work area where the billets are assimilated into squared groupings ready for loading or charging into the feeder.

8. When answering a feeder request for a charge, the crane, as soon as it releases any billets it might be carrying, will load the feed table. Another charge will be immediately prepared for that feeder unless another feeder calls for a charge; in which case the crane will load that feeder and then proceed to prepare charge(s) for any feeders not having a charge in reserve.

9. Breaks occur throughout the plant. Therefore, no crane activity occurs during any of the breaks.

10. Crane travel is uninterrupted. Lift trucks, etc. don't get in the way of the crane.

11. The assumed level of manufacturing activity will be for mobilization.

12. The crane operator has sufficient skill and is unemcumbered by union control or management policy to allow him to operate the crane at maximum speed. He could, thus, start the X and Y movements*, simultaneously, before completely clearing a railroad car or bay stock-pile containing a load of billets, i.e., not be confined to slow rectangular motion.

13. When computing travel times and distances, the X and Y center line coordinates of the bays, work areas, feeders, and railroad cars are used to calculate the distance between these objects.

DISCUSSION

After making some preliminary test runs to validate the model, two runs were made to verify the adequacy of the 200-feet-per-minute top velocity of the proposed new crane. Both runs used the previously described priority and bay layout in APPENDIX A plus the numeric inputs as described in APPENDIX B.

To review the major numeric items, the top velocity in the X and Y direction was entered as a uniform distribution ranging between 150 and 200 feet-per-minute. This range allowed for operator-to-operator and circumstance-to-circumstance variation. Additionally, the acceleration and deceleration rates in the X and Y directions were entered as a constant of 1-foot-per-second squared. Since 200 feet-per-minute is equivalent to only 2.23 miles per hour, it was generally believed that acceleration and deceleration to and from this level would take place at the maximum rate of 1-foot-per-second squared. Further, at this maximum acceleration rate, the small distance of 5.56 feet is required to achieve this top velocity of 200 feet-per-minute when starting from a standstill. These runs were simulated for a period in excess of 1 year under steady state conditions. Additionally, these runs did not have any unload queue build-up and all the bays in the storage yard had an inventory of 175 billets--1 heat. Run 1 represented a fairly good way of operating. While not optimal, the bay layout and priority scheme used was believed to be near optimal if management kept the work or staging areas in their present location as exhibited on the layout in APPENDIX A. Under these conditions, the crane was able to handle billets at a fast enough rate to enable it to be idle 27% of the average day with an additional break time (2 coffee and 1 lunch and 1 shift) idleness of nearly 18%. Additionally, the feed tables had to wait an average of only 2-3/4 minutes for a recharge. Once, feeder table number 2 had to wait 9.19 minutes for a recharge; however, the histogram plots of wait times reveal that this situation has very

*The X direction is the direction of travel parallel to the crane rails. The Y direction is perpendicular to the rails. See the bay layout in APPENDIX A.

little probability of occurrence. These histograms showed that, in general, the feed table recharge wait time was 5 minutes or less 95% of the time, and about 6-1/4 minutes or less 99% of the time. It was further observed in some of the validation runs that moving the work area or staging area directly across the railroad tracks to the open space presently on the layout and utilizing the present work area for storage space could significantly reduce the feed table recharge wait time.

Input data for run 2 was the same as for run 1 except the bay priorities were inverted, i.e., the bays farther away from the feed tables were used the most. This setup represents a very poor operating procedure. Under these conditions, the crane was idle only about 7% of the typical day. The average feed table wait time increased about 1-3/4 minutes to yield an average of 4-1/2 minutes. Additionally, the maximum wait times observed increased along with an exhibited downward shift in the wait time histograms. However, under these adverse operating conditions, the crane still performed adequately.

Finally, a third run was made to observe how the crane would respond to a shock load. Run 3 was initiated at the end of run 1 using the ending values of the simulation variables obtained at the end of run 1 with the exception of an addition of 1 month's consumption of inventory being placed in the unload queues. It took the crane 770 hours or about 1-1/4 months to empty the unload queues and thus return to steady state conditions. While the crane was working off this extra load, business was being conducted as usual. It would thus appear that this response is more than adequate since management does not expect any shocks of this magnitude to be imposed on the system.

CONCLUSION

The computer runs reviewed in the DISCUSSION section amply illustrate that the 200-feet-per-minute top velocity gantry crane proposed by the Army Corps of Engineers should more than adequately be able to handle the proposed mobilization workload. Further, it is apparent that the priority arrangement of bays and the location of the work or staging areas can critically affect the crane workload. It is strongly urged that this model be exercised to optimize the preceding 2 parameters.

Finally, the various runs made for this study along with a critical review by the Scranton management indicates that the model is very realistic. Thus, the objectives of this study as listed in the PURPOSE section of this report have been satisfactorily completed.

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APPENDIX A

BAY LAYOUT

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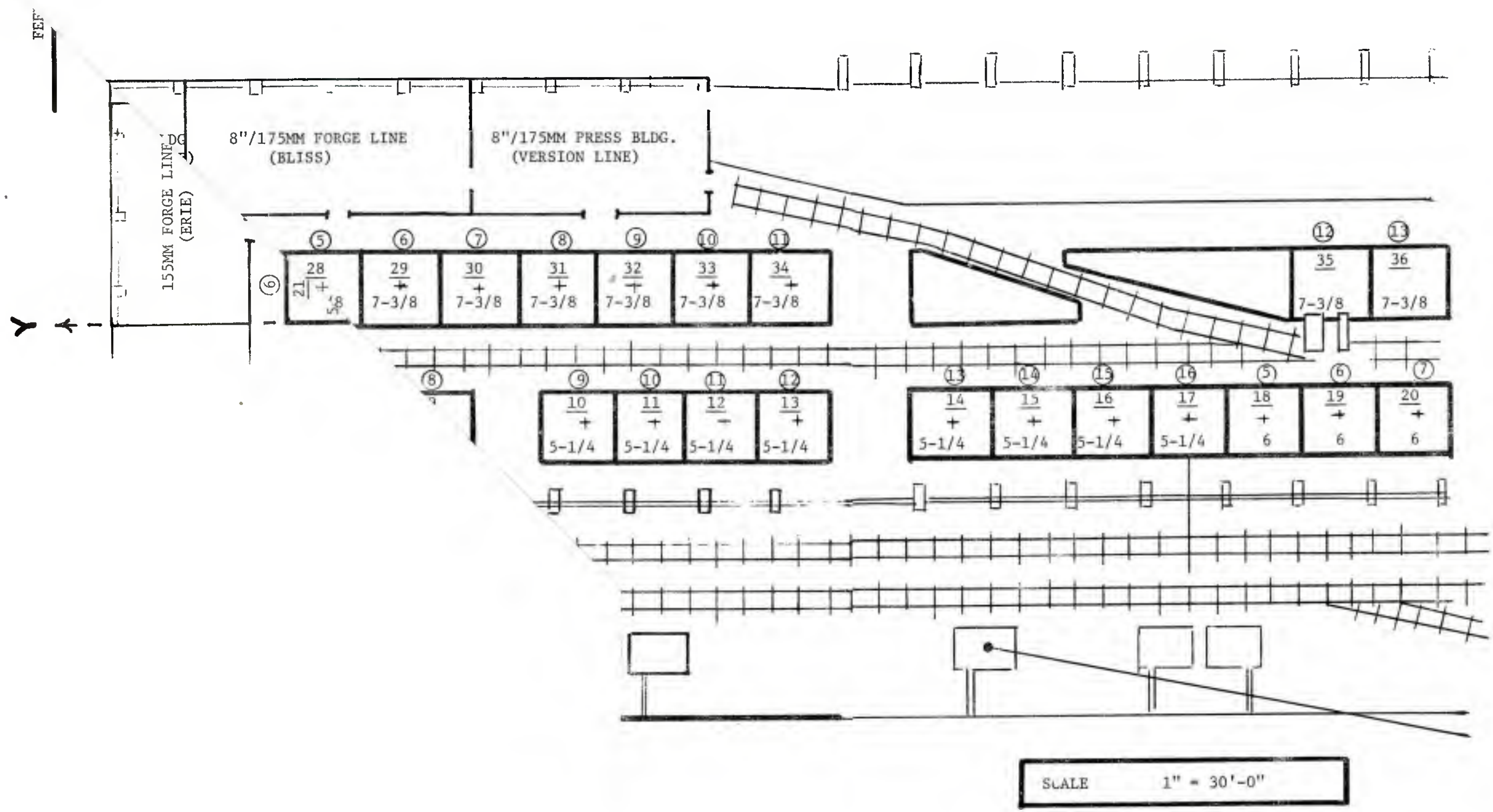

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APPENDIX B

CARD LAYOUT

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APPENDIX B

CARD LAYOUTS AND DATA

A. CONTROL CARDS

First Card

Col 1 (Format I1) Enter a zero in this column or leave blank if the event and inventory listing is desired for the length of time constrained by the times entered in fields 2 (cols 7-12) and 3 (cols 13-18) of this card. Otherwise, enter a 1 in this column to suppress the listing.

Col 2 (Format I1) Enter a zero in this column or leave blank if the bay trace listing is desired for the length of time constrained by the times entered in fields 2 (cols 7-12) and 3 (cols 13-18) of this card. Otherwise, enter a 1 in this column to suppress the listing.

Col 3 (Format I1) Enter a zero in this column or leave blank if the time listing is desired for the length of time constrained by the times entered in fields 2 (cols 7-12) and 3 (cols 13-18) of this card. Otherwise, enter a 1 in this column to suppress the listing.

Col 4 (Format I1) Enter a zero in this column or leave blank if the distance listing is desired for the length of time constrained by the times entered in fields 2 (cols 7-12) and 3 (cols 13-18) of this card. Otherwise, enter a 1 in this column to suppress the listing.

Col 5 (Format I1) Enter a zero in this column or leave blank if a 50 observation listing of generàtions of the stochastic data entered in this program is desired. Otherwise, enter a 1 in this column to suppress the listing.

Col 6 (Format I1) Enter a zero in this column or leave blank if a time vs. inventory plot of the bays is desired and a histogram plot of the work areas is desired. Otherwise, enter a 1 in this column to suppress this listing.

Cols 7-12 (Format F6.0) Enter (in minutes) the time when it is desired to start listing the entries of columns 1-4 above.

Cols 13-18 (Format F6.0) Enter (in minutes) the time when it is desired to stop listing the data in the preceding defined lists.

Cols 19-24 (Format F6.0) Enter (in minutes) the time when it is desired to stop the simulation.

Cols 25-26 (Format F2.0) Enter (in minutes) the length of time desired between intervals when taking observations of the simulation.

Cols 27-30 (Format F4.1) Enter (in feet) according to the origin defined in the yard layout, the X coordinate of the center line of the crane magnet when starting the simulation.

Cols 31-34 (Format F4.1) Enter (in feet) the Y coordinate as defined in the preceding field.

Cols 35-44 (Format I10) Enter the value initially assigned to the seed of the uniform (0 to 1) random number generator. The last value of the seed will be punched out at the end of the run. This seed may then be used for a follow on run, thus enabling the user to make a replication over a different sequence of random numbers. (A suggested initial seed is 435459 - IBM's RANDU).

Cols 45-46 (Format I2) Enter the type of material desired to be unloaded first - 0 (zero) or blank = no particular choice, 1 = 5-1/4, 2 = 6, 3 = 7-3/8. If something other than 0 (zero) or blank is entered in this field, some of the indicated type of billets must reside in the unload heat queue.

Cols 47-48 (Format I2) Enter the bay number where the billets are to be unloaded. Leave blank or enter a 0 (zero) if it is desired to let the program select the bay.

Cols 49-50 (Format I2) Enter the heat level of the preceding bay which is receiving the billets being unloaded. Leave this field blank or enter a 0 (zero) if it is desired to let the program select the heat level.

Cols 51-52 (Format I2) Enter the number of the bay currently supplying the 5-1/4 inch feed table with billets. Leave blank or enter a 0 (zero) if it is desired to let the program perform this task.

Cols 53-54 (Format I2) Enter the number of the bay currently supplying the 6 inch feed table with billets. Leave blank or enter a 0 (zero) if it is desired to let the program perform this task.

Cols 55-56 (Format I2) Enter the number of the bay currently supplying the 7-3/8 inch feed table with billets. Leave blank or enter a 0 (zero) if it is desired to let the program perform this task.

Cols 57-58 (Format I2) Enter the heat level of the bay currently providing the 5-1/4 inch billets. Leave this field blank or enter a 0 (zero) if it is desired to let the program select this heat level.

Cols 59-60 (Format I2) Enter the heat level of the bay currently providing the 6 inch billets. Leave this field blank or enter a 0 (zero) if it is desired to let the program select this heat level.

Cols 61-62 (Format I2) Enter the heat level of the bay currently providing the 7-3/8 inch billets. Leave this field blank or enter a 0 (zero) if it is desired to let the program select this heat level.

Cols 63-64 (Format I2) Enter the minimum number of 5-1/4 inch billets required in the squaring-up charges work area.

Cols 65-66 (Format I2) Enter the minimum number of 6 inch billets required in the squaring up charges work area.

Cols 67-68 (Format I2) Enter the minimum number of 7-3/8 inch billets required in the squaring-up charges work area.

Cols 69-70 (Format I2) Enter the number of 5-1/4 inch billets in a standard charge or loading of the feeder.

Cols 71-72 (Format I2) Enter the number of 6 inch billets in a standard charge or loading of the feeder.

Cols 73-74 (Format I2) Enter the number of 7-3/8 inch billets in a standard charge or loading of the feeder.

Cols 75-76 (Format I2) Enter the maximum number of 5-1/4 inch billets the crane can carry to the feeder.

Cols 77-78 (Format I2) Enter the maximum number of 6 inch billets the crane can carry to the feeder.

Cols 79-80 (Format I2) Enter the maximum number of 7-3/8 inch billets the crane can carry to the feeder.

Second Card

Cols 1-6 (Format F6.0) Enter (in feet), according to the origin defined in the yard layout, the X coordinate of the center line of the 5-1/4 inch billet feeder.

Cols 7-12 (Format F6.0) Enter (in feet) the Y coordinate as defined in the preceding field.

Cols 13-18 (Format F6.0) Enter (in feet), according to the origin defined in the yard layout, the X coordinate of the center line of the 6 inch billet feeder.

Cols 19-24 (Format F6.0) Enter (in feet) the Y coordinate as defined in the preceding field.

Cols 25-30 (Format F6.0) Enter (in feet), according to the origin defined in the yard layout, the X coordinate of the center line of the 7-3/8 inch billet feeder.

Cols 31-36 (Format F6.0) Enter (in feet) the Y coordinate as defined in the preceding field.

Cols 37-42 (Format F6.0) Enter (in feet), according to the origin defined in the yard layout, the X coordinate of the center line of the 5-1/4 inch billet work area used for squaring-up a group of billets to be loaded into the 5-1/4 inch billet feeder.

Cols 43-48 (Format F6.0) Enter (in feet) the Y coordinate as defined in the preceding field.

Cols 49-54 (Format F6.0) Enter (in feet), according to the origin defined in the yard layout, the X coordinate of the center line of the 6 inch billet work area used for squaring-up a group of billets to be loaded into the 6 inch billet feeder.

Cols 55-60 (Format F6.0) Enter (in feet) the Y coordinate as defined in the preceding field.

Cols 61-66 (Format F6.0) Enter (in feet), according to the origin defined in the yard layout, the X coordinate of the center line of the 7-3/8 inch billet work area used for squaring-up a group of billets to be loaded into the 7-3/8 inch billet feeder.

Cols 67-72 (Format F6.0) Enter (in feet) the Y coordinate as defined in the preceding field.

Cols 73-80 Blank.

<u>Third Card</u>

Cols 1-4 (Format I4) Enter the number of billets in the oldest 5-1/4 inch billet heat now residing in the unload queue.

Continue the preceding using fields of 4 consecutive columns until the list of 5-1/4 heats queued-up is completely exhausted or until the 21 heat is required. Since only 20 heats are currently allowed, entering more heats will require expanding the check variable maxque and all the arrays mnemonically dimensioned in terms of this variable as shown in subroutine load.

<u>Fourth Card</u>

Follow the same procedure as outlined for the third card except enter data for the 6 inch billets.

<u>Fifth Card</u>

Follow the same procedure as outlined for the third card except enter data for the 7-3/8 inch billets.

Sixth Card

Cols 1-8 (Format F8.0) Enter the future time when independent event number 1 will next occur.

Continue the preceding using fields of 8 consecutive columns until future event times for all ten independent events have been entered.

B. BAY CARDS

(One card is required for each bay. The last card of this series must have -9 punched in cols 1-2 and the rest of the card must be left blank.)

Cols 1-2 (Format I2) Enter the bay number (the bays must be sequentially numbered).

Cols 3-4 (Format I2) If this bay is dedicated to storing 5-1/4 inch billets, enter a bay priority number (lower numbers are of higher priority). Otherwise, leave this field blank.

Cols 5-6 (Format I2) If this bay is dedicated to storing 6 inch billets, enter a bay priority number (lower numbers are of higher priority). Otherwise, leave this field blank.

Cols 7-8 (Format I2) If this bay is dedicated to storing 7-3/8 inch billets, enter a bay priority number (lower numbers are of higher priority). Otherwise, leave this field blank.

Cols 9-14 (Format F6.0) Enter (in feet), according to the origin defined in the yard layout, the X coordinate of the center line of this bay.

Cols 15-20 (Format F6.0) Enter (in feet) the Y coordinate as defined in the preceding field.

Cols 21-25 (Format I5) Enter the maximum number of billets allowed in this bay.

Cols 26-30 (Format I5) Enter the actual number of billets currently inventoried in this bay for the first heat level. Continue entering, using fields of 5 consecutive columns until the billets of all heats residing in this bay have been entered.

NOTE: All the cards described up to this point, except for the first 26 columns of the first card (card one of the control cards), are punched out at the end of each run with the end of run data entered. However, the future event times (card six of the control cards) have been reduced by the magnitude of the simulation stop time (columns 19-24 of control card number 1). This setup will enable breaking long simulation runs into segments, thereby, enabling examining pieces of the run via use of some or all of the various long form event-by-event printouts offered in this program.

C. STOCHASTIC DATA CARDS CARRY FIX POINT (A CONSTANT) AND RANDOM (STOCHASTIC) DATA INTO THE PROGRAM.

The types of distributions available and the definitions of inputs for the various fields are as follows:

TYPE OF DISTRIBUTION	FIELD NO. 1	FIELD NO. 2	FIELD NO. 3	FIELD NO. 4	FIELD NO. 5	FIELD NO. 6	FIELD NO. 7
CONSTANT	1	CONSTANT					
UNIFORM	2	MIN OBS	MAX OBS				
TRIANGULAR	3	MIN OBS	MAX OBS	MOST LIKELY OBS			
NORMAL	4	MIN OBS	MAX OBS	MEAN	STANDARD DEVIATION		
LOGNORMAL	5	MIN OBS	MAX OBS	MEAN	STANDARD DEVIATION		
GAMMA	6	MIN OBS	MAX OBS	MEAN	STANDARD DEVIATION		
WEIBULL*	7	MIN OBS	MAX OBS	SCALE PARAMETER	SHAPE PARAMETER		
ERLANG	8	MIN OBS	MAX OBS	MEAN	NO. OF EXPONETIAL DEVIATES		
(EXPONETIAL)	8	MIN OBS	MAX OBS	MEAN	1		
CHI SQUARE	9	MIN OBS	MAX OBS	NO. DEGREES FREEDOM			

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*THE MINIMUM OBSERVATION IS THE LOCATION PARAMETER.

TYPE OF DISTRIBUTION	FIELD NO. 1	FIELD NO. 2	FIELD NO. 3	FIELD NO. 4	FIELD NO. 5	FIELD NO. 6	FIELD NO. 7
BETA**	10	MIN OBS	MAX OBS	A	B		
POISSON	11	MIN OBS	MAX OBS	MEAN			
PASCAL***	12	MIN OBS	MAX OBS	P	K		
(GEOMETRIC)***	12	MIN OBS	MAX OBS	P	K= 1		
BINOMIAL****	13	MIN OBS	MAX OBS	P	N		
HYPERGEOMETRIC*****	14	MIN OBS	MAX OBS	P	N	M	
HISTOGRAM******	15	A	B	C	D	E	F

** $F(X) = \dfrac{G(A+B)X^{A-1}(1-X)^{B-1}}{G(A)G(B)}$

A = Greater than Zero
B = Greater than Zero
G = Gamma Function

*** $F(X) = \binom{K+X-1}{X} P^K Q^X$

$X = 0, 1, 2...$
$Q = 1-P$

**** $F(X) = \binom{N}{X} P^X Q^{N-X}$

$X = 0, 1, 2...N$
$Q = 1-P$

***** $F(X) = \dfrac{\binom{NP}{X}\binom{NQ}{M-X}}{\binom{N}{M}}$

$X = 0, 1, 2...N$
$M-X = 0, 1, 2...NQ$
$Q = 1-P$

****** 1. A - Enter the value of the left hand boundary of probability Cell No. 1.

2. B - Enter the probability of realizing Cell No. 1.

3. C - Enter the value of the right hand boundary of probability Cell No. 1 and the left hand boundary of probability Cell No. 2.

4. D - Enter the probability of realizing Cell No. 2.

5. E - Enter the value of the right hand boundary of probability Cell No. 2 and the left hand boundary of probability Cell No. 3.

6. F - Enter the probability of realizing Cell No. 3.

7. In Field No. 1 of the next card enter the value of the right hand boundary of probability Cell No. 3 and the left hand boundary of probability Cell No. 4.

8. Continue entering the elements of the histogram in these 7 field patterns using as many cards as necessary until the entire histogram has been completely loaded.

9. The next field after the last field used to load the histogram data must have a -999.0 entered in it to mark the end of the histogram information.

The stochastic data card's field layouts are as follows:

Cols 1-3 (Format I3) Enter the key number the program uses to fetch an observation from a given stochastic input. The data definitions of the key numbers are as follows:

KEY NO. DATA DEFINITION

1. The distribution of resupply calls from Feeder No. 1. First it is necessary to calculate the time between charges given the mobilization rate of production per month and the working hours per month. Since the calls of Feeders 2 and 3 require similar information, some of the necessary preliminary calculations required for them will also be exhibited.

ROUND	GUN	MOB RATE No./Month	SCRAP 5%	MULT WT In Lbs	PLANT INPUT Tons/Month	RAW STOCK (TONS/MONTH) 5-1/4"	6"	7-3/8"
M107	155MM	100,000	5000	107	5618	7865		
M110	155MM	40,000	2000	107	2247			
M437	175MM	40,000	2000	172	3612		3612	
M106	8 Inch	40,000	2000	220	4620			6384
M404	8 Inch	15,000	750	224	1764			

Number of Working Hours Per Month, Using 1976 as a Base for Calculations:

1. Jan 31 - 5 = 26	5. May 31 - 6 = 25	9. Sept 30 - 5 = 25
2. Feb 29 - 6 = 23	6. Jun 30 - 4 = 26	10. Oct 31 - 7 = 24
3. Mar 31 - 4 = 27	7. July 31 - 5 = 26	11. Nov 30 - 5 = 25
4. Apr 30 - 4 = 26	8. Aug 31 - 5 = 26	12. Dec 31 - 5 = 26

********Sums to 305 Working Days / Year (1976)

$$305 \frac{\text{Working Days}}{\text{Year}} \times \frac{\text{Year}}{12 \text{ Months}} = 25.42 \quad \frac{\text{Working Days}}{\text{Month}} \times 24 \quad \frac{\text{Contact Hours}}{\text{Working Day}} = 610 \quad \frac{\text{Contact Hours}}{\text{Month}}$$

Breaks Total $\frac{80 \text{ Minutes}}{8 \text{ Contact}}$ Hours

$$\text{Actual Working Hours} = (610)\left(1 - \frac{80}{480}\right) = \frac{508 \text{ Working Hours}}{\text{Month}}$$

$$\frac{7865 \frac{\text{Tons}}{\text{Month}}}{10 \frac{\text{Billets}}{\text{Charge}} \times \frac{1874 \frac{\text{Lbs}}{\text{Billet}}}{2000 \frac{\text{Lbs}}{\text{Ton}}}} = 839.38 \quad \frac{\text{Charges}}{\text{Month}}$$

Thus

$$\frac{508 \frac{\text{Working Hrs}}{\text{Month}} \times 60 \frac{\text{Minutes}}{\text{Hour}}}{839.38 \frac{\text{Charges}}{\text{Month}}} = 36.31 \quad \frac{\text{Minutes}}{\text{Charge}}$$

To create some manufacturing variability, it will be assumed that this 36.31 minutes between charges is the mean of a normal distribution having 95 % of its area within 15% of its mean.

Thus, the STD DEV $= \frac{(0.15)\ (36.31)}{1.96} = 2.78$, also, 3 STD DEV CUT OFFS = 27.97 AND 44.64.

2. The distribution of resupply calls from Feeder No. 2. Following the calculations for Feeder No. 1 yields the following:

$$\frac{3612 \frac{\text{Tons}}{\text{Month}}}{13 \frac{\text{Billets}}{\text{Charge}} \times \frac{2448 \frac{\text{Lbs}}{\text{Billet}}}{2000 \frac{\text{Lbs}}{\text{Ton}}}} = 227.00 \quad \frac{\text{Charges}}{\text{Month}}$$

, Thus

$$\frac{508 \frac{\text{Working Hrs}}{\text{Month}} \times 60 \frac{\text{Minutes}}{\text{Hour}}}{227.00 \frac{\text{Charges}}{\text{Month}}} = 134.27 \quad \frac{\text{Minutes}}{\text{Charge}}$$

Thus, the STD DEV $= \frac{(0.15)\ (134.27)}{1.96} = 10.28$ also 3 STD DEV CUT-OFFS = 103.44 and 165.10.

3. The Distribution of resupply calls from Feeder No. 3. Following the calculations for Feeder No. 1 yields the following:

$$\frac{6384 \ \frac{\text{Tons}}{\text{Month}}}{\dfrac{13 \ \frac{\text{Billets}}{\text{Charge}} \times 3698 \ \frac{\text{Lbs}}{\text{Billets}}}{2000 \ \frac{\text{Lbs}}{\text{Ton}}}} = 265.59 \ \frac{\text{Charges}}{\text{Month}} \quad \text{THUS} \quad \frac{508 \ \frac{\text{Working Hrs}}{\text{Month}} \times 60 \ \frac{\text{Minutes}}{\text{Hour}}}{265.59 \ \frac{\text{Charges}}{\text{Month}}} = 114.76 \ \frac{\text{Minutes}}{\text{Charge}}$$

$$\text{Thus, the STD DEV} = \frac{(0.15)\ (114.76)}{1.96} = 8.78 \quad \text{ALSO} \quad \text{3 STD DEV CUT OFFS} = 88.41 \text{ and } 141.11.$$

4. Arrival of a 5-1/4 Inch Heat.

$$\frac{7865 \ \frac{\text{Tons}}{\text{Month}}}{\dfrac{175 \ \frac{\text{Billets}}{\text{Heat}} \times 1874 \ \frac{\text{Lbs}}{\text{Billet}}}{2000 \ \frac{\text{Lbs}}{\text{Ton}}}} = 47.96 \ \frac{\text{Heats}}{\text{Month}} \quad \text{OR} \quad \frac{610 \ \frac{\text{Contact Hours}}{\text{Month}} \times 60 \ \frac{\text{Minutes}}{\text{Hour}}}{47.96 \ \frac{\text{Heats}}{\text{Month}}} = 763.06 \ \frac{\text{Minutes}}{\text{Heat Arrival}}$$

Since most arrivals are poisson, it will be assumed this arrival is also poisson distributed. Further, 3 STD DEV CUT OFFS will be employed since the variate will essentially be generated as a normal deviate because of its high parameter value.

Thus 3 STD DEV CUT OFFS = 680.19 and 845.93.

5. Arrival of a 6 Inch Heat.

$$\frac{3612 \frac{\text{Tons}}{\text{Month}}}{175 \frac{\text{Billets}}{\text{Heat}} \times \frac{2448 \frac{\text{Lbs}}{\text{Billet}}}{2000 \frac{\text{Lbs}}{\text{Ton}}}} = 16.86 \frac{\text{Heats}}{\text{Month}} \quad \text{OR} \quad \frac{610 \frac{\text{Contact Hours}}{\text{Month}} \times 60 \frac{\text{Minutes}}{\text{Hour}}}{16.86 \frac{\text{Heats}}{\text{Month}}} = 2170.47 \frac{\text{Minutes}}{\text{Heat Arrival}}$$

Thus, 3 STD DEV CUT OFFS = 2030.70 and 2310.23.

6. Arrival of a 7-3/8 Inch Heat.

$$\frac{6384 \frac{\text{Tons}}{\text{Month}}}{175 \frac{\text{Billets}}{\text{Heat}} \times \frac{3698 \frac{\text{Lbs}}{\text{Billet}}}{2000 \frac{\text{Lbs}}{\text{Ton}}}} = 19.73 \frac{\text{Heats}}{\text{Month}} \quad \text{OR} \quad \frac{610 \frac{\text{Contact Hours}}{\text{Month}} \times 60 \frac{\text{Minutes}}{\text{Hour}}}{19.73 \frac{\text{Heats}}{\text{Month}}} = 1855.08 \frac{\text{Minutes}}{\text{Heat Arrival}}$$

Thus, 3 STD DEV CUT OFFS = 1725.87 and 1984.29.

7. The time from the first coffee break to the next occurrence of this same event was entered as a constant of 480 minutes.

8. The time from the lunch break to the next occurrence of this same event was entered as a constant of 480 minutes.

9. The time from the second coffee break to the next occurrence of this same event was entered as a constant of 480 minutes.

10. The time from the shift break to the next occurrence of this same event was entered as a constant of 480 minutes.

11. The time required to pick billets out of a railroad car was entered as a Triangular Distribution having a minimum time of 0.25 minutes, a maximum time of 1.5 minutes, and a most-likely time of 0.75 minutes. This is the time required between stopping X and Y motion to position the magnet over the car and starting X and Y motion to transport the load of billets to the storage bay.

12. The time required to swing a load of billets into position so this load can be stacked on the pile in a storage bay was entered as Triangular Distribution having a minimum time of 0.25 minutes, a maximum time of 1.0 minutes, and a most-likely time of 0.5 minutes. Since this task is essentially accomplished by a man on the pile, the crane's travel to the pile has been completed. Therefore, this time is defined as the time from the end of travel--to the pile--to the start of setting the load of billets down on the pile.

13. The time required to set the load of billets on the storage pile begins at the end of swing time and continues until the X and Y travel away from the pile begins. This time includes pile shape up time and billet packing time. This time was entered as a Triangular Distribution having a minimum time of 0.5 minutes, a maximum time of 2.0 minutes, and a most-likely time of 0.85 minutes.

14. The X distance in feet between the center line of the railroad car and the receiving storage bay was entered as a histogram as follows: 20% of the time the distance will be between 0 and 50 feet, 20% of the time the the distance will be between 50 and 100 feet, 30% of the time the distance will be between 100 and 150 feet, and finally 30% of the time the distance will be between 150 and 200 feet.

15. The number of 5-1/4 inch billets picked out of a railroad car per unit pick was entered as a Triangular Distribution having 1.0 as the minimum number of billets, 12.0 as the maximum number of billets, and 8.0 as the most-likely number of billets.

16. The number of 6 inch billets picked out of a railroad car per unit pick was entered as a Triangular Distribution having 1.0 as the minimum number of billets, 12.0 as the maximum number of billets, and 7.0 as the most-likely number of billets.

17. The number of 7-3/8 inch billets picked out of a railroad car per unit pick was entered as a Triangular Distribution having 1.0 as the minimum number of billets, 8.0 as the maximum number of billets, and 6.0 as the most-likely number of billets.

18. The length of the morning coffee break was entered as a constant of 15.0 minutes.

19. The length of the lunch break was entered as a constant of 35.0 minutes.

20. The length of the afternoon coffee break was entered as a constant of 15.0 minutes.

21. The length of the shift break was entered as a constant of 15.0 minutes.

22. The time required to pick billets off of the storage pile in some bay was entered as a Triangular Distribution, having a minimum time of 0.25 minutes, a maximum time of 1.0 minutes, and a most-likely time of 0.5 minutes. This is the time expended between stopping all X and Y motion to positioning the magnet over the bay and starting X and Y motion to transport the load of billets to the work area.

23. The number of 5-1/4 inch billets picked off of a storage pile per unit pick was entered as a Triangular Distribution having 1.0 as the minimum number of billets, 10.0 as the maximum number of billets, and 10.0 as the most-likely number of billets.

24. The number of 6 inch billets picked off of a storage pile per unit pick was entered as a Triangular Distribution having 1.0 as the minimum number of billets, 9.0 as the maximum number of billets, and 9.0 as the most-likely number of billets.

25. The number of 7-3/8 inch billets picked off of a storage pile per unit pick was entered as a Triangular Distribution having 1.0 as the minimum number of billets, 7.0 as the maximum number of billets, and 7.0 as the most-likely number of billets.

26. The time required to set a load of billets down in the work area begins when the X and Y travel into the work area ends and continues until the X and Y travel away from the set down position begins. This time was entered as a Triangular Distribution having a minimum value of 0.1 minutes, a maximum value of 0.5 minutes and a most-likely value of 0.3 minutes.

27. The time required to pick up a charge or a portion of a charge was entered as a Triangular Distribution having a minimum value of 0.25 minutes, a maximum value of 1.0 minutes and a most-likely value of 0.5 minutes. This is the time expended between stopping X and Y travel to positioning the magnet over the charge and the starting of X and Y travel to transport the charge to the feed table.

28. The time required to set a charge or a portion of a charge on the feed table begins when X and Y travel to the feeder table ends and continues until X and Y travel away from the feeder table begins. This time was entered as a Triangular Distribution having a minimum value of 0.25 minutes, a maximum value of 0.75 minutes, and a most-likely value of 0.45 minutes.

29. The time required to square up a group of loose billets into a square array of tightly packed billets ready for loading on the feed table was entered as a Triangular Distribution having a minimum value of 0.75 minutes, a maximum value of 2.0 minutes and a most-likely value of 1.25 minutes. This is time expended between stopping X and Y travel to positioning the magnet over the loose billets in the work area and starting of X and Y travel away from the work area to the next task.

30. Acceleration in the X direction was entered as a constant of 1.0 feet-per-second squared.

31. Deceleration in the X direction was entered as a constant of 1.0 feet-per-second squared.

32. The top velocity attainable in the X direction was entered as a Uniform Distribution ranging from 150 - 200 feet-per-minute.

33. Acceleration in the Y direction was entered as a constant of 1.0 feet-per-second squared.

34. Deceleration in the Y direction was entered as a constant of 1.0 feet-per-second squared.

35. The top velocity attainable in the Y direction was entered as a Uniform Distribution ranging from 150 - 200 feet-per-minute.

36. The size of a typical 5-1/4 inch heat was entered as a constant of 175 billets.

37. The size of a typical 6 inch heat was entered as a constant of 175 billets.

38. The size of a typical 7-3/8 inch heat was entered as a constant of 175 billets.

39. The typical number of 5-1/4 inch billets on a railroad car was entered as a constant of 60 billets.

40. The typical number of 6 inch billets on a railroad car was entered as a constant of 60 billets.

41. The typical number of 7-3/8 inch billets on a railroad car was entered as a constant of 60 billets.

42. The time in minutes a feeder is allowed to wait before scratching the run was entered as a constant of 20.

Cols 4-5 (Format I2) The cards required to accomplish this task must be sequentially numbered. The histogram option is the only input option which may require more than 1 card to input all the necessary

data elements. Therefore, for distributions and a constant, the user need only enter a 1 in this field. However, for histogram data the first card must have a 1 entered in this field, a 2 must be entered in this field for card 2, and so on for as many cards as necessary.

Cols 6-15 (Format F10.0) Enter the necessary data for Field 1 as defined above.

Cols 16-25 (Format F10.0) Enter the necessary data for Field 2 as defined above.

Cols 26-35 (Format F10.0) Enter the necessary data for Field 3 as defined above.

Cols 36-45 (Format F10.0) Enter the necessary data for Field 4 as defined above.

Cols 46-55 (Format F10.0) Enter the necessary data for Field 5 as defined above.

Cols 56-65 (Format F10.0) Enter the necessary data for Field 6 as defined above.

Cols 66-75 (Format F10.0) Enter the necessary data for Field 7 as defined above.

Cols 76-80 Leave Blank.

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APPENDIX C

ERROR MESSAGES

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APPENDIX C

ERROR MESSAGES

Number and Description of Error Messages.

1233 - Length of time between systems simulation samples is either negative or larger than the simulation stop time.

1244 - Starting time for taking a sample of the processing of the independent events is larger than the ending time.

1255 - Starting time for taking a system simulation sample of the processing of the independent events is negative.

1266 - X coordinate of the crane's starting point is beyond the boundaries of the yard.

1277 - Y coordinate of the crane's starting point is beyond the boundaries of the yard.

1288 - Initial value assigned to the Random Number Seed is less than or equal to zero.

1299 - The pool level for one of the types of billets is less than the number of billets contained in a charge.

1300 - The number of billets contained in a charge is a nonpositive number.

1311 - The maximum number of billets that the crane can carry for one of the types of billets is a nonpositive number.

1322 - The X coordinate of one of the feeders is beyond the boundaries of the yard.

1333 - The Y coordinate of one of the feeders is beyond the boundaries of the yard.

1344 - The X coordinate of one of the work areas is beyond the boundaries of the yard.

1355 - The Y coordinate of one of the work areas is beyond the boundaries of the yard.

1377 - The initial queue of heats in railroad cars waiting to be unloaded for one of the three types of billets is negative.

1399 - An initial value of one of the independent events is negative.

1433 - The bay number for the preceding card was feasible.

1455 - The current maximum number of billets allowed in the bay card just read in is not a positive number.

1466 - One of the heats being stored in the bay just read is either negative or larger than the maximum number of billets allowed.

1488 - The total number of billets entered in the bay just read in is larger than the maximum number allowed.

1499 - The X coordinate of the bay currently being read in is beyond the boundaries of the yard.

1500 - The Y coordinate of the bay currently being read in is beyond the boundaries of the yard.

1544 - More than just one priority has been assigned to the bay currently being read in.

1555 - The priority number assigned to this bay is faulty.

1577 - The type of material and the bay receiving billets currently being unloaded do not have acceptable consistent values, i.e., they must both be zero or both be greater than zero at the same time.

1599 - Either the type of material being unloaded, the bay receiving the material, or the heat level is beyond the maximum values allowed. These items exceed their check variables of MAXTYP, MAXBAY or MAXHET.

1611 - The bay designated to receive the billets queued for unloading does not accommodate this type of material.

1644 - The heat level of the bay receiving material is faulty.

1655 - The queue, which was designated to be unloaded, is empty.

1677 - One of the bays providing billets to one of the feed tables and its heat level does not have consistent values. They must both be zero or both be greater than zero at the same time.

1699 - One of the bays providing billets to the feed tables or its heat level exceeds its maximum allowable level. One or both of these variables exceed their check variables of MAXBAY or MAXHET.

1711 - One of the bays designated to providing billets to a given feed table does not store the correct type of billet for the table it is supplying.

1744 - The heat level of one of the bays supplying billets to a feed table is faulty. It is not aimed at the top of the pile.

1822 - A -999.0 was not entered as the last item of data for the histogram information previously read in.

1844 - The pointer or internal reference number assigned to the stochastic data being read in is faulty.

1866 - The distribution number assigned to the stochastic data being read in is faulty.

1899 - The storage area for stochastic data has been exceeded.

1922 - The card number is out of sequence for the stochastic data being read in.

1977 - The Lognormal Distribution requested on the previous input card requires positive non-zero parameters.

2000 - The Gamma Distribution requested on the previous input card requires positive non-zero parameters.

2022 - The Gamma Distribution requested on the previous input card has a standard deviation which is too large or the mean is too small to yield at least one exponential deviate.

2044 - The Weibull Distribution requested on the previous input card requires positive non-zero parameters.

2077 - The Erlang Distribution requested on the previous input card requires positive non-zero parameters and integer exponential deviates.

2100 - The Chi Square Distribution requested on the previous input card requires positive non-zero parameters and integer degrees of freedom.

2133 - The Beta Distribution requested on the previous input card requires positive non-zero parameters.

2155 - The Poisson Distribution requested on the previous input card requires positive non-zero parameters.

2200 - The Pascal Distribution requested on the previous input card does not meet one of the following requirements:

1. The value assigned to P must lie between 0 and 1.

2. The value assigned to K must be a positive integer.

3. The minimum observation must not be negative.

PASCAL - $F(X) = \binom{K+X-1}{X} P^K Q^X$ X = 0, 1, 2... AND Q = 1-P

2244. The Binomial Distribution requested on the previous input card does not meet one of the following requirements:

1. The value assigned to P must lie between 0 and 1.

2. The value assigned to N must be a positive integer.

3. The minimum observation must not be negative.

BINOMIAL - $F(X) = \binom{N}{X} P^X Q^{N-X}$ X = 0, 1, 2---N AND Q = 1-P

2288 - The Hypergeometric Distribution requested on the previous input card does not meet one of the following requirements:

1. The value assigned to P must lie between 0 and 1.

2. The value assigned to N must be a positive integer.

3. The value assigned to M must be a positive integer less than N.

4. The minimum observation must not be negative.

HYPERGEOMETRIC - $F(X) = \dfrac{\binom{NP}{X}\binom{NQ}{M-X}}{\binom{N}{M}}$ X = 0, 1, ---NP; M-X = 0, 1, ---NQ; Q = 1-P

2311 - The distribution requested on the previous card requires a positive standard deviation which was not entered.

2333 - The distribution requested on the previous card has a mean value which lies outside the minimum - maximum value range.

2355 - The distribution requested on the previous card has a zero or negative minimum - maximum value range.

2399 - The histogram data just entered has a probability cell with a negative value entered in it.

2400 - The histogram data just entered has a probability cell with the same right and left hand boundaries with a positive density.

2422 - The histogram data just entered indicates that a probability cell has a left hand boundary which is larger than the right hand boundary.

2433 - The sum of all the probability cells for the histogram data just entered does not sum to one.

2655 - At least one of the bays requires more heat levels. Expand check variable MAXHET and all the arrays mnemonically dimensioned in terms of this variable.

2777 - A feeder had to wait for resupplying longer than the time allowed as per stochastic input number 42.

2811 - At least one of the heat queues requires more heat levels. Expand check variable MAXQUE and all the arrays mnemonically dimensioned in terms of this variable.

2955 - The yard is cleaned out of one of the three different types of billets. The error number listed after this one indicates the type of billet (1 = 5-1/4, 2 = 6, 3 = 7-3/8) the yard is out of.

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APPENDIX D

COMPUTER LISTING OF PROGRAM

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```
0001              0COMMON CLOCK, SETUP, TNEXT, XNOW, YNOW, XTRAV, YTRAV, XTIME,YTIME,
                  1YCENTR, SMSTOP, TLOOK, CLAST, TSTART, TSTOP, X, Y, Z, INPT, IOUT,
                  2IPNH, IWF1, IWF2, IWF3, MAXBAY, MAXSTO, MAXKEY, MAXTYP, MAXEVT,
                  3MAXQUE, MAXHET, IPS1, IPS2, IPS3, IPS4, IPS5, IPS6, IVENT, ISEED,
                  4IRROR, LOOK, ICOUNT, ISAVE, MATUNL, IPTBAY, ITOP, INVTAL, ITRAV,
                  5JTRAV, WAIT, NWAIT, WMIN, WMAX, NGET, NCOUNT
             C
             C     SCRANTON UNLOADING AND FEEDING CRANE SIMULATION
             C
0002          1111 CALL LOAD
0003               IF(IRROR.GT.0) GO TO 1111
0004               CALL SIM
0005               IF(INVTAL.LE.0) GO TO 1111
0006               CALL PLOTTS
0007               GO TO 1111
0008               END
```

```
0001          SUBROUTINE ERROR (N)
0002         0COMMON CLOCK, SETUP, TNEXT, XNOW, YNOW, XTRAV, YTRAV, XTIME,YTIME,
             1YCENTR, SMSTOP, TLOOK, CLAST, TSTART, TSTOP, X, Y, Z, INPT, IOUT,
             2IPNH, IWF1, IWF2, IWF3, MAXBAY, MAXSTO, MAXKEY, MAXTYP, MAXEVT,
             3MAXQUE, MAXHET, IPS1, IPS2, IPS3, IPS4, IPS5, IPS6, IVENT, ISEED,
             4IRROR, LOOK, ICOUNT, ISAVE, MATUNL, IPTBAY, ITOP, INVTAL, ITRAV,
             5JTRAV, WAIT, NWAIT, WMIN, WMAX, NGET, NCOUNT
        C
        C     THIS SUBROUTINE LIST ERRORS
        C
0003          IRROR = IRROR + 1
0004          WRITE (IOUT,1122) IRROR, N
0005     1122 FORMAT (1H0, 20X, I4, 17H,  E R R O R  NO., I6)
0006          RETURN
0007          END
```

```
0001              SUBROUTINE LOAD                                                    GLM  320
0002             0COMMON CLOCK, SETUP, TNEXT, XNOW, YNOW, XTRAV, YTRAV, XTIME,YTIME,GLM  330
                 1YCENTR, SMSTOP, TLOOK, CLAST, TSTART, TSTOP, X, Y, Z, INPT, IOUT, GLM  340
                 2IPNH, IWF1, IWF2, IWF3, MAXBAY, MAXSTO, MAXKEY, MAXTYP, MAXEVT,   GLM  350
                 3MAXQUE, MAXHET, IPS1, IPS2, IPS3, IPS4, IPS5, IPS6, IVENT, ISEED, GLM  360
                 4IRROR, LOOK, ICOUNT, ISAVE, MATUNL, IPTBAY, ITOP, INVTAL, ITRAV,  GLM  370
                 5JTRAV, WAIT, NWAIT, WMIN, WMAX, NGET, NCOUNT                      GLM  380
0003             0COMMON/STO/STORE( 300), KEY(50), ETIME(10), IBAYP(36,3), XBAY(36),GLM  390
                 1YBAY(36), INVB(36,6), MXINVB(36), INVBT(36), IUSE(36), INVQ(3,20),GLM  400
                 2INVQT(3),IPOOL(3),LEVELP(3),IFEED(3),IBTOP(3),NCHAR(3),NFEED(3),  GLM  410
                 3MASK(3), XFEED(3), YFEED(3), XWORK(3), YWORK(3), MININV(3),       GLM  420
                 4MAXINV(3), AVEINV(3), NTIME(10), STIME(10), SMIN(10), SMAX(10)    GLM  430
0004              DIMENSION IDIST(14)                                               GLM  440
0005              DATA IDIST/2,3,4,5,5,5,5,5,4,5,4,5,5,6/                           GLM  450
            C                                                                       GLM  460
            C     THIS SUBROUTINE LOADS THE DATA, INITIALIZE I/O PARAMETERS         GLM  470
            C                                                                       GLM  480
0006              INPT = 5                                                          GLM  490
0007              IOUT = 6                                                          GLM  500
0008              IPNH = 7                                                          GLM  510
0009              IWF1 = 8                                                          GLM  520
0010              IWF2 = 9                                                          GLM  530
0011              IWF3 = 10                                                         GLM  540
0012              REWIND IWF1                                                       GLM  550
0013              REWIND IWF2                                                       GLM  560
0014              REWIND IWF3                                                       GLM  570
            C                                                                       GLM  580
            C     NOTE---THE DIMENSIONS ASSIGNED TO THE DIMENSIONED VARIABLES IN THEGLM  590
            C            COMMON AND THE VALUES ASSIGNED TO THE CHECK VARIABLES DE-  GLM  600
            C            FINED BELOW MUST BE KEPT CONSISTANT WITH THE FOLLOWING     GLM  610
            C            MNEMONIC DIMENSIONING SCHEME.                              GLM  620
            C                                                                       GLM  630
            C    0COMMON/STO/STORE(MAXSTO), KEY(MAXKEY), ETIME(MAXEVT),IBAYP(MAXBAY,GLM  640
            C    1MAXTYP), XBAY(MAXBAY), YBAY(MAXBAY), INVB(MAXBAY,MAXHET),         GLM  650
            C    2MXINVB(MAXBAY), INVBT(MAXBAY), IUSE(MAXBAY), INVQ(MAXTYP,MAXQUE), GLM  660
            C    3INVQT(MAXTYP), IPOOL(MAXTYP), LEVELP(MAXTYP), IFEED(MAXTYP),      GLM  670
            C    4IBTOP(MAXTYP), NCHAR(MAXTYP), NFEED(MAXTYP), MASK(MAXTYP),        GLM  680
            C    5XFEED(MAXTYP), YFEED(MAXTYP), XWORK(MAXTYP), YWORK(MAXTYP),       GLM  690
            C    6MININV(MAXTYP), MAXINV(MAXTYP), AVEINV(MAXTYP), STIME(10),        GLM  700
            C    7NTIME(10), SMIN(10), SMAX(10)                                     GLM  710
            C                                                                       GLM  720
            C     CHECK VARIABLES                                                   GLM  730
            C        MAXBAY - MAXIMUM NUMBER OF BAYS                                GLM  740
            C        MAXSTO - MAXIMUM STORAGE OF STORE                              GLM  750
            C        MAXKEY - MAXIMUM STORAGE OF THE POINTER TO STORE (KEY)         GLM  760
            C        MAXTYP - MAXIMUM NUMBER OF TYPES OF STEEL                      GLM  770
            C        MAXEVT - MAXIMUM NUMBER OF INDEPENDENT EVENTS                  GLM  780
            C        MAXHET - MAXIMUM NUMBER OF HEATS EACH BAY CAN ACCOMMODATE      GLM  790
            C        MAXQUE - MAXIMUM NUMBER OF HEATS OF EACH TYPE OF BILLET WHICH  GLM  800
            C                 CAN QUE UP FOR UNLOADING                              GLM  810
            C                                                                       GLM  820
0015              MAXBAY= 36                                                        GLM  830
0016              MAXSTO= 300                                                       GLM  840
```

```
0017            MAXKEY= 50
0018            MAXTYP= 3
0019            MAXEVT= 10
0020            MAXHET= 6
0021            MAXQUE= 20
          C
          C     INITIALIZE THE FOLLOWING WORK VARIABLES
          C        IRROR  - ERROR COUNTER
          C        SETUP  - LARGEST NUMBER THE COMPUTER CAN HANDLE
          C        CLOCK  - TIME KEEPER IN THE SYSTEM
          C        CLAST  - LAST TIME A SNAPSHOT OF THE SYSTEM WAS TAKEN
          C        LOOK   - RECORDS NUMBER OF TIMES THE SNAPSHOTS WERE TAKEN
          C        ICOUNT - COUNTER ON THE DETAIL INDEPENDENT EVENT LISTING
          C        ITRAV  - NO. OF TIMES TRAVEL IN THE X DIRECTION OCCURRED
          C        JTRAV  - NO. OF TIMES TRAVEL IN THE Y DIRECTION OCCURRED
          C        XTRAV  - TOTAL TRAVEL IN THE X DIRECTION
          C        YTRAV  - TOTAL TRAVEL IN THE Y DIRECTION
          C        XTIME  - TOTAL TRAVEL TIME IN THE X DIRECTION
          C        YTIME  - TOTAL TRAVEL TIME IN THE Y DIRECTION
          C        YCENTR - CENTER OF THE YARD - THE RR TRACKS
          C        WAIT   - TOTAL AMOUNT OF TIME EVENTS WAIT FOR PROCESSING
          C        NWAIT  - NUMBER OF TIMES EVENTS WAITED FOR PROCESSING
          C        WMIN   - MINIMUM WAIT TIME
          C        WMAX   - MAXIMUM WAIT TIME
          C        NGET   - NUMBER OF TIMES REQUIRED A HAUL BEFORE FEEDING
          C        NCOUNT - COUNTS NUMBER OF TIMES A FEEDING WAS MADE
          C
0022            IRROR= 0
0023            SETUP= 9.0E70
0024            CLOCK= 0.0
0025            CLAST= 0.0
0026            LOOK = 0
0027            ICOUNT = 0
0028            ITRAV= 0
0029            JTRAV= 0
0030            XTRAV= 0.0
0031            YTRAV= 0.0
0032            XTIME = 0.0
0033            YTIME = 0.0
0034            YCENTR = 30.0
0035            WAIT = 0.0
0036            NWAIT = 0
0037            WMIN = SETUP
0038            WMAX =-SETUP
0039            NGET = 0
0040            NCOUNT = 0
          C
          C     INITIALIZE AND READ THE FOLLOWING
          C        IBAYP  - BAY USAGE PRIORITY FOR EACH OF THE VARIOUS STEELS
          C        XBAY   - X COORDINATE OF EACH BAY
          C        YBAY   - Y COORDINATE OF EACH BAY
          C        MXINVB - MAXIMUM NUMBER OF BILLETS ALLOWED IN EACH BAY
          C        INVB   - INVENTORY IN EACH BAY - NO. OF BILLETS PER HEAT
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              C         INVBT  - TOTAL INVENTORY IN EACH BAY
              C         IUSE   - NO. OF TIMES A HEAT WAS STORED & RETRIEVED FROM A BAY
              C         IPS1   - PRINT SWITCH FOR THE EVENT AND INVENTORY LISTING
              C         IPS2   - PRINT SWITCH FOR THE BAY TRACE LISTING
              C         IPS3   - PRINT SWITCH FOR THE TIME LISTING
              C         IPS4   - PRINT SWITCH FOR THE DISTANCE LISTING
              C         IPS5   - PRINT SWITCH FOR STOCHASTIC DATA SAMPLES
              C         IPS6   - PRINT SWITCH FOR BAY, QUE AND POOL PLOTS
              C         TSTART - STARTING TIME FOR LISTING A BLOW BY BLOW ACCOUNT
              C         TSTOP  - ENDING TIME FOR LISTING A BLOW BY BLOW ACCOUNT
              C         SMSTOP - SIMULATION STOP TIME
              C         TLOOK  - LENGTH OF TIME BETWEEN TAKING SAMPLES FROM THE SYSTEM
              C         XNOW   - X COORDINATE OF SIMULATION STARTING POINT OF THE CRANE
              C         YNOW   - Y COORDINATE OF SIMULATION STARTING POINT OF THE CRANE
              C         ISEED  - RANDOM NUMBER GENERATOR SEED
              C         MATUNL - TYPE OF BILLET CURRENTLY BEING UNLOADED
              C         IPTBAY - BAY WHICH IS RECEIVING THE BILLETS BEING UNLOADED
              C         ITOP   - HEAT LEVEL (TOP OF PILE) IN RECEIVING BAY GETTING MAT.
              C         IFEED  - BAYS SUPPLYING BILLETS TO THE FEEDERS
              C         IBTOP  - HEAT LEVEL (TOP OF PILE) SUPPLYING BILLETS TO FEEDERS
              C
0041                DO 1144 I=1,MAXBAY
0042                IUSE(I) = 0
0043                DO 1133 J=1,MAXTYP
0044           1133 IBAYP(I,J) = 0
0045                XBAY(I) = 0.0
0046                YBAY(I) = 0.0
0047                INVBT(I) = 0
0048                MXINVB(I) = 0
0049                DO 1144 J=1,MAXHET
0050           1144 INVB(I,J) = 0
              C
              C         LEVELP - MINIMUM NO. OF BILLETS REQUIRED IN THE WORK POOL
              C         IPOOL  - NO. OF BILLETS READY FOR FEEDING INTO THE FEEDERS
              C         NCHAR  - NO. OF BILLETS IN A CHARGE
              C         NFEED  - MAX. NO. OF BILLETS THE CRANE CAN CARRY TO THE FEEDER
              C         XFEED  - X COORDINATE OF THE FEEDER
              C         YFEED  - Y COORDINATE OF THE FEEDER
              C         XWORK  - X COORDINATE OF THE WORK AREA
              C         YWORK  - Y COORDINATE OF THE WORK AREA
              C         INVQ   - INVENTORY IN EACH QUE - NO. BILLETS PER HEAT
              C         INVQT  - TOTAL INVENTORY IN EACH QUE
              C         ETIME  - CARRIES THE FUTURE TIME OF THE INDEPENDENT EVENTS
              C                   1. FEEDER # 1 CALL (FEEDER #1 PROCESS 5 1/4)
              C                   2. FEEDER # 2 CALL (FEEDER #2 PROCESS 6)
              C                   3. FEEDER # 3 CALL (FEEDER #3 PROCESS 7 3/8)
              C                   4. ARRIVAL OF A 5 1/4 INCH HEAT
              C                   5. ARRIVAL OF A 6 INCH HEAT
              C                   6. ARRIVAL OF A 7 3/8 INCH HEAT
              C                   7. MORNING COFFEE BREAK
              C                   8. LUNCH BREAK
              C                   9. AFTERNOON COFFEE BREAK
              C                  10. SHIFT BREAK
```

```
            C
 0051             0READ (INPT,1155) IPS1, IPS2, IPS3, IPS4, IPS5, IPS6, TSTART,TSTOP,
                  1SMSTOP, TLOOK, XNOW, YNOW, ISEED, MATUNL, IPTBAY, ITOP, IFEED,
                  2IBTOP, LEVELP, NCHAR, NFEED, (XFEED(I), YFEED(I), I=1,MAXTYP),
                  3(XWORK(I), YWORK(I), I=1,MAXTYP), ((INVQ(I,J), J=1,MAXQUE),
                  4I=1,MAXTYP), (ETIME(I), I=1,MAXEVT)
 0052        11550FORMAT (6I1, 3F6.0, F2.0, 2F4.1, I10, 18I2/ 12F6.2/ 20I4/ 20I4/
                  120I4/ 10F8.0)
 0053              IF(IPS1.EQ.9) STOP
 0054              WRITE (IOUT,1166) IPS1, IPS2, IPS3, IPS4, IPS5, IPS6
 0055        11660FORMAT(71H1PRINT SWITCH FOR THE EVENT AND INVENTORY LISTING(0-LIST
                  1, ELSE-NO LIST),14(1H-),I12/61H PRINT SWITCH FOR THE BAY TRACE LIS
                  2TING(0-LIST, ELSE-NO LIST),24(1H-),I12/56H PRINT SWITCH FOR THE TI
                  3ME LISTING(0-LIST, ELSE-NO LIST),29(1H-),I12/60H PRINT SWITCH FOR
                  4THE DISTANCE LISTING(0-LIST, ELSE-NO LIST),25(1H-),I12/63H PRINT S
                  5WITCH FOR STOCHASTIC DATA SAMPLES(0-LIST, ELSE-NO LIST),22(1H-),
                  6I12/63H PRINT SWITCH FOR BAY, QUE AND POOL PLOTS(0-LIST, ELSE-NO L
                  7IST), 22(1H-), I12)
 0056              WRITE (IOUT,1177) TSTART, TSTOP, SMSTOP, TLOOK, XNOW, YNOW, ISEED
 0057        11770FORMAT (75H0STARTING TIME FOR LISTING THE PROCESSING OF EACH OF TH
                  1E INDEPENDENT EVENTS, 10(1H-), F12.2/ 73H ENDING TIME FOR LISTING
                  2THE PROCESSING OF EACH OF THE INDEPENDENT EVENTS, 12(1H-), F12.2/
                  341H TIME WHEN THE SIMULATION WILL BE STOPPED, 44(1H-), F12.2/ 64H
                  4LENGTH OF TIME BETWEEN TAKING SAMPLE STATISTICS FROM THE SYSTEM,
                  521(1H-), F12.2/ 59H X COORDINATE OF THE SIMULATION STARTING POINT
                  6OF THE CRANE, 26(1H-), F12.2/ 59H Y COORDINATE OF THE SIMULATION S
                  7TARTING POINT OF THE CRANE, 26(1H-), F12.2/ 58H INITIAL VALUE OF T
                  8HE SEED FOR THE RANDOM NUMBER GENERATOR, 27(1H-), I12)
 0058              WRITE (IOUT,1188) MATUNL, IPTBAY, ITOP, IFEED, IBTOP
 0059        11880FORMAT (68H MATERIAL CURRENTLY BEING UNLOADED(0=NOTHING, 1=5 1/4,
                  12=6, 3=7 3/8), 17(1H-), I12/ 38H BAY RECEIVING MATERIAL BEING UNLO
                  2ADED, 47(1H-), I12/ 67H HEAT LEVEL IN RECEIVING BAY WHICH RECEIVES
                  3 MATERIAL BEING UNLOADED, 18(1H-), I12/ 1H , 91X, 5H5 1/4, 11X,
                  41H6, 7X, 5H7 3/8/ 41H BAYS CURRENTLY SUPPLYING THE FEED TABLES,
                  544(1H-), 3I12/ 80H HEAT LEVEL (TOP OF PILE) OF THE PRECEEDING BAYS
                  6 WHICH ARE SUPPLYING THE BILLETS, 5(1H-), 3I12)
 0060              WRITE (IOUT,1199) LEVELP, NCHAR, NFEED, XFEED, YFEED, XWORK, YWORK
 0061        11990FORMAT (72H MINIMUM NUMBER OF BILLETS DESIRED IN THE WORK POOL (IN
                  1ITIAL LEVEL ALSO), 13(1H-), 3I12/ 30H NUMBER OF BILLETS IN A CHARG
                  2E, 55(1H-), 3I12/ 60H MAXIMUM NUMBER OF BILLETS THE CRANE CAN CARR
                  3Y TO THE FEEDER, 25(1H-), 3I12/ 29H X COORDINATES OF THE FEEDERS,
                  456(1H-), 3F12.2/ 29H Y COORDINATES OF THE FEEDERS, 56(1H-),3F12.2/
                  532H X COORDINATES OF THE WORK AREAS, 53(1H-), 3F12.2/ 32H Y COORDI
                  6NATES OF THE WORK AREAS, 53(1H-), 3F12.2/ 49H NUMBER OF BILLETS PE
                  7R HEAT QUED UP FOR UNLOADING, 34(1H-))
 0062              DO 1200 J=1,MAXQUE
 0063         1200 WRITE (IOUT,1211) J, (INVQ(I,J), I=1,3)
 0064         1211 FORMAT (1H+, 79X, I5, 3I12/)
 0065              WRITE (IOUT,1222) (I, I=1,MAXEVT), ETIME, (I, I=1,MAXHET)
 0066        12220FORMAT (42H INITIAL VALUES FOR THE INDEPENDENT EVENTS/ 1H ,
                  110(I11,1H.)/ 1H , 10F12.2/ 4H1BAY, 6X, 8HPRIORITY, 13X, 11HCOORDIN
                  2ATES, 2X, 3HMAX, 2X, 20HNO. BILLETS PER HEAT/ 1H , 4X, 5H5 1/4,
                  35X, 1H6, 1X, 5H7 3/8, 9X, 1HX, 9X, 1HY, 5X, 10I5)
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            C                                                                       GLM 2420
            C      MAKE AN ERROR CHECK ON THE CONTROL CARDS AND INITIALIZE          GLM 2430
            C         INVTAL - COUNTS NO. OF TIMES A TOTAL INVENTORY CHECK WAS MADE GLM 2440
            C         MININV - RECORDS THE MINIMUM TOTAL INVENTORY FOR THE RUN      GLM 2450
            C         MAXINV - RECORDS THE MAXIMUM TOTAL INVENTORY FOR THE RUN      GLM 2460
            C         AVEINV - RECORDS THE AVERAGE TOTAL INVENTORY FOR THE RUN      GLM 2470
            C      IF THE STOP TIME FOR LISTING THE PROCESSING OF THE EVENTS IS EQUALGLM 2480
            C         TO THE END OF RUN TIME, SET STOP LIST TIME TO A LARGE VALUE   GLM 2490
            C                                                                       GLM 2500
  0067             IF(TSTOP.EQ.SMSTOP) TSTOP = SETUP                                GLM 2510
  0068             IF(TLOOK.LE.0.0.OR.TLOOK.GT.SMSTOP) CALL ERROR (1233)            GLM 2520
  0069             IF(TSTOP.LT.TSTART) CALL ERROR (1244)                            GLM 2530
  0070             IF(TSTART.LT.0.0) CALL ERROR (1255)                              GLM 2540
  0071             IF(XNOW.LT.-51.0.OR.XNOW.GT.570.0) CALL ERROR (1266)             GLM 2550
  0072             IF(YNOW.LT.0.0.OR.YNOW.GT.100.0) CALL ERROR (1277)               GLM 2560
  0073             IF(ISEED.LE.0) CALL ERROR (1288)                                 GLM 2570
  0074             INVTAL = 0                                                       GLM 2580
  0075             DO 1366 I=1,MAXTYP                                               GLM 2590
  0076             MININV(I) = 999999                                               GLM 2600
  0077             MAXINV(I) =-999999                                               GLM 2610
  0078             AVEINV(I) = 0.0                                                  GLM 2620
  0079             IF(LEVELP(I).LT.NCHAR(I)) CALL ERROR (1299)                      GLM 2630
  0080             IF(NCHAR(I).LE.0) CALL ERROR (1300)                              GLM 2640
  0081             IF(NFEED(I).LE.0) CALL ERROR (1311)                              GLM 2650
  0082             IF(XFEED(I).LT.-51.0.OR.XFEED(I).GT.570.0) CALL ERROR (1322)     GLM 2660
  0083             IF(YFEED(I).LT.0.0.OR.YFEED(I).GT.100.0) CALL ERROR (1333)       GLM 2670
  0084             IF(XWORK(I).LT.-51.0.OR.XWORK(I).GT.570.0) CALL ERROR (1344)     GLM 2680
  0085             IF(YWORK(I).LT.0.0.OR.YWORK(I).GT.100.0) CALL ERROR (1355)       GLM 2690
  0086             IPOOL(I) = LEVELP(I)                                             GLM 2700
  0087             INVQT(I) = 0                                                     GLM 2710
  0088             DO 1366 J=1,MAXQUE                                               GLM 2720
  0089             INVQT(I) = INVQT(I) + INVQ(I,J)                                  GLM 2730
  0090        1366 IF(INVQ(I,J).LT.0) CALL ERROR (1377)                             GLM 2740
  0091             DO 1388 I=1,MAXEVT                                               GLM 2750
  0092        1388 IF(ETIME(I).LT.0.0) CALL ERROR (1399)                            GLM 2760
            C                                                                       GLM 2770
            C      READ IN THE BAY INFO                                             GLM 2780
            C                                                                       GLM 2790
  0093        1400 READ (INPT,1411) I, MASK, X, Y, J, (NTIME(K), K=1,MAXHET)        GLM 2800
  0094        1411 FORMAT (4I2, 2F6.0, 11I5)                                        GLM 2810
  0095             IF(I.EQ.-9) GO TO 1566                                           GLM 2820
  0096             WRITE (IOUT,1422) I, MASK, X, Y, J, (NTIME(K), K=1,MAXHET)       GLM 2830
  0097        1422 FORMAT (1H , I3, 3I6, 2F10.2, 11I5)                              GLM 2840
  0098             IF(I.GE.1.AND.I.LE.MAXBAY) GO TO 1444                            GLM 2850
  0099             CALL ERROR (1433)                                                GLM 2860
  0100             GO TO 1400                                                       GLM 2870
  0101        1444 IF(J.LE.0) CALL ERROR (1455)                                     GLM 2880
  0102             MXINVB(I) = J                                                    GLM 2890
  0103             DO 1477 K=1,MAXHET                                               GLM 2900
  0104             IF(NTIME(K).LT.0.OR.NTIME(K).GT.J) CALL ERROR (1466)             GLM 2910
  0105             INVBT(I) = INVBT(I) + NTIME(K)                                   GLM 2920
  0106        1477 INVB(I,K) = NTIME(K)                                             GLM 2930
  0107             IF(INVBT(I).GT.J) CALL ERROR (1488)                              GLM 2940
```

```
0108           XBAY(I) = X
0109           IF(X.LT.-51.0.OR.X.GT.570.0) CALL ERROR (1499)
0110           YBAY(I) = Y
0111           IF(Y.LT.0.0.OR.Y.GT.100.0) CALL ERROR (1500)
0112           DO 1511 K=1,MAXTYP
0113      1511 IBAYP(I,K) = MASK(K)
0114           N = 0
0115           K = 0
0116           DO 1533 L=1,MAXTYP
0117           IF(IBAYP(I,L).NE.0) GO TO 1522
0118           N = N + 1
0119           GO TO 1533
0120      1522 K = L
0121      1533 CONTINUE
0122           IF(N.NE.2) CALL ERROR (1544)
0123           IF(K.EQ.0) GO TO 1400
0124           J = IBAYP(I,K)
0125           IF(J.LE.0.OR.J.GT.MAXBAY) CALL ERROR (1555)
0126           GO TO 1400
         C
         C     CROSS CHECK BAY DATA WITH UNLOAD MATERIAL TYPE, BAY AND HEAT LEVEL
         C        POINTER DATA - FIRST CHECK PERMISSIBLE RANGE OF THE POINTERS
         C
0127      1566 IF(MATUNL.GT.0.AND.IPTBAY.GT.0.AND.ITOP.GT.0) GO TO 1588
0128           IF(MATUNL.EQ.0.AND.IPTBAY.EQ.0.AND.ITOP.EQ.0) GO TO 1666
0129           CALL ERROR (1577)
0130           GO TO 1666
0131      15880IF(MATUNL.LE.MAXTYP.AND.IPTBAY.LE.MAXBAY.AND.ITOP.LE.MAXHET)
              1GO TO 1600
0132           CALL ERROR (1599)
0133           GO TO 1666
         C
         C     CHECK BAY-BILLET TYPE, HEAT LEVEL AND MATERIAL IN UNLOAD QUE
         C
0134      1600 IF(IBAYP(IPTBAY,MATUNL).LE.0) CALL ERROR (1611)
0135           DO 1622 I=1,MAXHET
0136           IF(INVB(IPTBAY,I).EQ.0) GO TO 1633
0137      1622 J = I
0138      1633 IF(ITOP.LT.J.OR.ITOP.GT.J+1) CALL ERROR (1644)
0139           IF(INVQ(MATUNL,1).LE.0) CALL ERROR (1655)
         C
         C     CROSS CHECK BAY DATA WITH FEEDER AND HEAT LEVEL POINTER DATA
         C
0140      1666 DO 1766 I=1,MAXTYP
0141           M = IFEED(I)
0142           N = IBTOP(I)
0143           IF(M.GT.0.AND.N.GT.0) GO TO 1688
0144           IF(M.EQ.0.AND.N.EQ.0) GO TO 1766
0145           CALL ERROR (1677)
0146           GO TO 1766
0147      1688 IF(M.LE.MAXBAY.AND.N.LE.MAXHET) GO TO 1700
0148           CALL ERROR (1699)
0149           GO TO 1766
```

```
           C
           C      CHECK BILLET TYPE FOR THIS BAY AND HEAT LEVEL
           C
 0150        1700 IF(IBAYP(M,I).LE.0) CALL ERROR (1711)
 0151             DO 1722 J=1,MAXHET
 0152             K = MAXHET + 1 - J
 0153             IF(INVB(M,K).NE.0) GO TO 1755
 0154        1722 CONTINUE
 0155        1733 CALL ERROR (1744)
 0156             GO TO 1766
 0157        1755 IF(K.NE.N) GO TO 1733
 0158        1766 CONTINUE
           C
           C      READ IN STOCHASTIC DATA
           C
 0159             KOUNT = 0
 0160             M = -9999
 0161             ISAVE = -9999
 0162             WRITE (IOUT,1777) (I, I=1,10)
 0163        17770FORMAT (1H1, 20X, 15HSTOCHASTIC DATA/ 2H0 , 6HKEY NO, 7I16/ 1H ,
                 17X, 3I16, 7H---ETC.)
 0164        1788 K = -9999
 0165        1799 READ (INPT,1800) I, J, (STIME(N), N=1,7)
 0166        1800 FORMAT (I3, I2, 7F10.0)
 0167             IF(I.EQ.-99) GO TO 2444
 0168             IF(I.GT.LOOK) LOOK = I
 0169             WRITE (IOUT,1811) I, J, (STIME(N), N=1,7)
 0170        1811 FORMAT (1H , I4, I3, 7F16.3)
 0171             IF(I.EQ.K) GO TO 1911
 0172             IF(M.NE.15) GO TO 1833
 0173             IF(ISAVE.NE.-9998) CALL ERROR (1822)
 0174        1833 IF(I.GE.1.AND.I.LE.MAXKEY) GO TO 1855
 0175             CALL ERROR (1844)
 0176             GO TO 1788
           C
           C      CREATE WORK VARIABLES, LOAD KEY, INCREMENT THE COUNTER
           C
 0177        1855 M0 = KOUNT + 1
 0178             M1 = KOUNT + 2
 0179             M2 = KOUNT + 3
 0180             M3 = KOUNT + 4
 0181             M4 = KOUNT + 5
 0182             M5 = KOUNT + 6
 0183             KEY(I) = M0
 0184             K = I
 0185             L = 0
 0186             M = STIME(1) + 0.1
 0187             IF(M.GE.1.AND.M.LE.15) GO TO 1877
 0188             CALL ERROR (1866)
 0189             GO TO 1788
 0190        1877 IF(M.EQ.15) GO TO 1911
 0191             N = IDIST(M)
 0192             KOUNT = KOUNT + N
```

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0193             IF(KOUNT.LE.MAXSTO) GO TO 1900                                    GLM 4010
0194        1888 CALL ERROR (1899)                                                 GLM 4020
0195             STOP                                                              GLM 4030
0196        1900 IF(N.GE.1) STORE(M0) = STIME(1)                                   GLM 4040
0197             IF(N.GE.2) STORE(M1) = STIME(2)                                   GLM 4050
0198             IF(N.GE.3) STORE(M2) = STIME(3)                                   GLM 4060
0199             IF(N.GE.4) STORE(M3) = STIME(4)                                   GLM 4070
0200             IF(N.GE.5) STORE(M4) = STIME(5)                                   GLM 4080
0201             IF(N.GE.6) STORE(M5) = STIME(6)                                   GLM 4090
0202        1911 L = L + 1                                                         GLM 4100
0203             IF(J.EQ.L) GO TO 1933                                             GLM 4110
0204             CALL ERROR (1922)                                                 GLM 4120
0205             GO TO 1788                                                        GLM 4130
           C                                                                       GLM 4140
           C     CHECK DISTRIBUTION PARAMETERS                                     GLM 4150
           C                                                                       GLM 4160
0206        19330GO TO (1788,2344,1944,1955,1966,1999,2033,2066,2099,2122,2144,    GLM 4170
               12188,2222,2266,2366),M                                             GLM 4180
           C                                                                       GLM 4190
           C     TRIANGULAR                                                        GLM 4200
           C                                                                       GLM 4210
0207        1944 X = STORE(M3)                                                     GLM 4220
0208             GO TO 2322                                                        GLM 4230
           C                                                                       GLM 4240
           C     NORMAL                                                            GLM 4250
           C                                                                       GLM 4260
0209        1955 X = STORE(M3)                                                     GLM 4270
0210             Y = STORE(M4)                                                     GLM 4280
0211             GO TO 2300                                                        GLM 4290
           C                                                                       GLM 4300
           C     LOGNORMAL                                                         GLM 4310
           C                                                                       GLM 4320
0212        1966 X = STORE(M3)                                                     GLM 4330
0213             Y = STORE(M4)                                                     GLM 4340
0214             IF(STORE(M1).GT.0.0.AND.X.GT.0.0) GO TO 1988                      GLM 4350
0215             CALL ERROR (1977)                                                 GLM 4360
0216             GO TO 1788                                                        GLM 4370
0217        1988 Z = ALOG((Y*Y)/(X*X) + 1.0)                                       GLM 4380
0218             STORE(M3) = ALOG(X) - 0.5*Z                                       GLM 4390
0219             STORE(M4) = SQRT(Z)                                               GLM 4400
0220             GO TO 2300                                                        GLM 4410
           C                                                                       GLM 4420
           C     GAMMA                                                             GLM 4430
           C                                                                       GLM 4440
0221        1999 X = STORE(M3)                                                     GLM 4450
0222             Y = STORE(M4)                                                     GLM 4460
0223             IF(STORE(M1).GT.0.0.AND.X.GT.0.0.AND.STORE(M4).GT.0.0) GO TO 2011 GLM 4470
0224             CALL ERROR (2000)                                                 GLM 4480
0225             GO TO 1788                                                        GLM 4490
0226        2011 Z = Y*Y                                                           GLM 4500
0227             STORE(M3) = X/Z                                                   GLM 4510
0228             STORE(M4) = X/STORE(M3)                                           GLM 4520
0229             IF(STORE(M4).LE.0.0) CALL ERROR (2022)                            GLM 4530
```

```
0230              GO TO 2300
            C
            C     WEIBULL
            C
0231         20330IF(STORE(M1).GE.0.0.AND.STORE(M3).GT.0.0.AND.STORE(M4).GT.0.0)
                 1GO TO 2055
0232              CALL ERROR (2044)
0233              GO TO 1788
0234         2055 STORE(M4) = 1.0/STORE(M4)
0235              GO TO 2344
            C
            C     ERLANG
            C
0236         2066 X = STORE(M3)
0237              N = STORE(M4) + 0.001
0238              Z = N
0239             0IF(STORE(M1).GT.0.0.AND.X.GT.0.0.AND.STORE(M4).GT.0.0.AND.
                 1STORE(M4).EQ.Z) GO TO 2088
0240              CALL ERROR (2077)
0241              GO TO 1788
0242         2088 STORE(M3) = STORE(M4)/X
0243              Y = STORE(M4)/(STORE(M3)*STORE(M3))
0244              GO TO 2300
            C
            C     CHI SQUARE
            C
0245         2099 X = STORE(M3)
0246              N = X + 0.001
0247              Z = N
0248              IF(STORE(M1).GT.0.0.AND.Z.EQ.X.AND.X.GT.0.0) GO TO 2111
0249              CALL ERROR (2100)
0250              GO TO 1788
0251         2111 Y = 2.0*X
0252              ISAVE = N/2
0253              M0 = ISAVE*2
0254              IF(N.NE.M0) ISAVE = -ISAVE
0255              STORE(M3) = ISAVE
0256              GO TO 2300
            C
            C     BETA
            C
0257         21220IF(STORE(M1).GT.0.0.AND.STORE(M3).GT.0.0.AND.STORE(M4).GT.0.0)
                 1GO TO 2344
0258              CALL ERROR (2133)
0259              GO TO 1788
            C
            C     POISSON
            C
0260         2144 IF(STORE(M1).GE.0.0.AND.STORE(M3).GT.0.0) GO TO 2166
0261              CALL ERROR (2155)
0262              GO TO 1788
0263         2166 IF(STORE(M3).LE.10.0) GO TO 2177
0264              KOUNT = KOUNT + 1
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0265             IF(KOUNT.GT.MAXSTO) GO TO 1888
0266             STORE(M0) = 4.0
0267             STORE(M4) = SQRT(STORE(M3))
0268             GO TO 1955
0269        2177 X = STORE(M3)
0270             STORE(M3) = EXP(-STORE(M3))
0271             GO TO 2322
           C
           C     PASCAL
           C
0272        2188 IF(STORE(M3).LE.0.0.OR.STORE(M3).GE.1.0) GO TO 2199
0273             N = STORE(M4) + 0.001
0274             Z = N
0275             IF(Z.EQ.STORE(M4).AND.N.GT.0.AND.STORE(M1).GE.0.0) GO TO 2211
0276        2199 CALL ERROR (2200)
0277             GO TO 1788
0278        2211 X = (STORE(M4)*(1.0 - STORE(M3)))/STORE(M3)
0279             Y = X/STORE(M3)
0280             STORE(M3) = -ALOG(1.0 - STORE(M3))
0281             GO TO 2300
           C
           C     BINOMIAL
           C
0282        2222 IF(STORE(M3).LE.0.0.OR.STORE(M3).GE.1.0) GO TO 2233
0283             N = STORE(M4) + 0.001
0284             Z = N
0285             IF(Z.EQ.STORE(M4).AND.N.GT.0.AND.STORE(M1).GE.0.0) GO TO 2255
0286        2233 CALL ERROR (2244)
0287             GO TO 1788
0288        2255 X = STORE(M4)*STORE(M3)
0289             Y = X*(1.0 - STORE(M3))
0290             GO TO 2300
           C
           C     HYPERGEOMETRIC
           C
0291        2266 IF(STORE(M3).GT.0.0.AND.STORE(M3).LT.1.0) GO TO 2299
0292        2277 CALL ERROR (2288)
0293             GO TO 1788
0294        2299 N = STORE(M4) + 0.001
0295             Z = N
0296             ISAVE = STORE(M5) + 0.001
0297             X = ISAVE
0298            0IF(Z.NE.STORE(M4).OR.X.NE.STORE(M5).OR.N.LE.1.OR.
                1ISAVE.LE.0.OR.N.LE.ISAVE.OR.STORE(M1).LT.0.0) GO TO 2277
0299             X = STORE(M5)*STORE(M3)
0300             Z = (STORE(M4) - STORE(M5))/(STORE(M4) - 1.0)
0301             Y = X*(1.0 - STORE(M3))*Z
           C
           C     CHECK FOR POSITIVE VARIANCE, MEAN WITHIN MIN-MAX, MIN-MAX OKAY
           C
0302        2300 IF(Y.LE.0.0) CALL ERROR (2311)
0303        2322 IF(X.LT.STORE(M1).OR.X.GT.STORE(M2)) CALL ERROR (2333)
0304        2344 IF(STORE(M1).GE.STORE(M2)) CALL ERROR (2355)
```

```
0305            GO TO 1788
          C
          C     STORE HISTOGRAM DATA
          C
0306       2366 DO 2377 N=1,7
0307            KOUNT = KOUNT + 1
0308            IF(KOUNT.GT.MAXSTO) GO TO 1888
0309            STORE(KOUNT) = STIME(N)
0310            IF(STIME(N).EQ.-999.0) GO TO 2388
0311       2377 CONTINUE
0312            GO TO 1799
          C
          C     CHECK OUT THE HISTOGRAM
          C
0313       2388 ISAVE = -9998
0314            M5 = KOUNT - 1
0315            X = 0.0
0316            DO 2411 N=M2,M5,2
0317            IF(STORE(N).LT.0.0) CALL ERROR (2399)
0318            X = X + STORE(N)
0319            IF(STORE(N-1).EQ.STORE(N+1).AND.STORE(N).GT.0.0) CALL ERROR (2400)
0320       2411 IF(STORE(N-1).GT.STORE(N+1)) CALL ERROR (2422)
0321            IF(X.GT.0.99.AND.X.LT.1.01) GO TO 1788
0322            CALL ERROR (2433)
0323            GO TO 1788
          C
          C     PRINT VARIABLE STORAGE UTILIZATION AND PREPARE FOR SIMULATION
          C
0324       2444 X = (100.0*FLOAT(KOUNT))/FLOAT(MAXSTO)
0325            WRITE (IOUT,2455) X
0326       2455 FORMAT (1H0, 20X, 36H0/0 OF STOCHASTIC STORAGE UTILIZED =, F6.2)
          C
          C     THE FOLLOWING 2 ARRAYS COLLECT THE NUMBER OF TIMES AND THE LENGTH
          C        OF TIME THE FOLLOWING ITEMS OF INTEREST OCCURRED
          C
          C        1. THE TIME THE CRANE SPENTS TRAVELING
          C        2. THE TIME THE CRANE IS NOT DOING ANYTHING
          C        3. THE TIME THE CRANE SPENTS PICKING BILLETS UP
          C        4. THE TIME THE CRANE SPENTS SETTING BILLETS DOWN
          C        5. THE TIME THE CRANE SPENTS SQUARING BILLETS UP FOR THE FEEDER
          C        6. THE TIME THE CRANE SPENTS SWING BILLETS INTO POSITION ON THE
          C           OPEN BAY STORAGE STACKS
          C        7. THE TIME THE CRANE IS IDLED BY BREAKS (COFFEE, LUNCH, SHIFT)
          C        8. THE TIME FEEDER NUMBER 1 WAITS FOR SERVICE
          C        9. THE TIME FEEDER NUMBER 2 WAITS FOR SERVICE
          C       10. THE TIME FEEDER NUMBER 3 WAITS FOR SERVICE
          C
0327            DO 2466 I=1,10
0328            NTIME(I) = 0
0329            STIME(I) = 0.0
0330            SMIN(I) = SETUP
0331       2466 SMAX(I) =-SETUP
0332            RETURN
0333            END
```

```
0001          SUBROUTINE SIM
0002         0COMMON CLOCK, SETUP, TNEXT, XNOW, YNOW, XTRAV, YTRAV, XTIME,YTIME,
             1YCENTR, SMSTOP, TLOOK, CLAST, TSTART, TSTOP, X, Y, Z, INPT, IOUT,
             2IPNH, IWF1, IWF2, IWF3, MAXBAY, MAXSTO, MAXKEY, MAXTYP, MAXEVT,
             3MAXQUE, MAXHET, IPS1, IPS2, IPS3, IPS4, IPS5, IPS6, IVENT, ISEED,
             4IRROR, LOOK, ICOUNT, ISAVE, MATUNL, IPTBAY, ITOP, INVTAL, ITRAV,
             5JTRAV, WAIT, NWAIT, WMIN, WMAX, NGET, NCOUNT
0003         0COMMON/STO/STORE( 300), KEY(50), ETIME(10), IBAYP(36,3), XBAY(36),
             1YBAY(36), INVB(36,6), MXINVB(36), INVBT(36), IUSE(36), INVQ(3,20),
             2INVQT(3),IPOOL(3),LEVELP(3),IFEED(3),IBTOP(3),NCHAR(3),NFEED(3),
             3MASK(3), XFEED(3), YFEED(3), XWORK(3), YWORK(3), MININV(3),
             4MAXINV(3), AVEINV(3), NTIME(10), STIME(10), SMIN(10), SMAX(10)
        C
        C     CHECK THE DISTRIBUTIONS FOR THEIR PERFORMANCE
        C
0004          IF(IPS5.NE.0) GO TO 2533
0005          L = ISEED
0006          M = 1
0007          N = 10
0008     2477 IF(N.GT.LOOK) N = LOOK
0009          WRITE (IOUT,2488) (I, I=M,N)
0010     2488 FORMAT (1H1, 20X, 23HSTOCHASTIC DATA SAMPLES/ 1H0, 6X, 10I12)
0011          DO 2500 I=1,50
0012          K = 0
0013          DO 2499 J=M,N
0014          K = K + 1
0015          CALL GEN(J)
0016     2499 ETIME(K) = X
0017     2500 WRITE (IOUT,2511) I, (ETIME(J), J=1,K)
0018     2511 FORMAT (1H , I5, 1H., 10F12.2)
0019          IF(N.EQ.LOOK) GO TO 2522
0020          M = M + 10
0021          N = N + 10
0022          GO TO 2477
        C
        C     INITIALIZE WORK VARIABLES
        C        NCAR   - NUMBER BILLET LEFT IN THE RAILROAD CAR BEING UNLOADED
        C        IPAGE  - PAGE COUNTER
        C        LINE   - LINE COUNTER
        C        WAITMX - MAX TIME AN EVENT WAITS BEFORE PROGRAM STOP
        C
0023     2522 ISEED = L
0024     2533 LOOK = 0
0025          NCAR   = 0
0026          IPAGE  = 1
0027          LINE   = 999
0028          CALL GEN(42)
0029          WAITMX = X
        C
        C     DETERMINE WHICH EVENT WILL OCCUR NEXT
        C
0030     2544 TNEXT = SETUP
0031          DO 2555 I=1,MAXEVT
```

```
      IF(ETIME(I).GE.TNEXT) GO TO 2555
      IVENT = I
      TNEXT = ETIME(I)
 2555 CONTINUE
      IF(TNEXT.LT.SMSTOP) GO TO 2566
      TNEXT = SMSTOP
      IVENT = 11
C
C     IF AN INDEPENDENT EVENT HAS NOT OCCURRED, DETERMINE IF A WORK AREA
C        (STAGGING AREA) NEEDS MORE RAW STOCK
C
 2566 IF(CLOCK.GE.TNEXT) GO TO 2722
      K = 0
      N = 0
      DO 2577 I=1,MAXTYP
      IF(IPOOL(I).GE.LEVELP(I)) GO TO 2577
      L = LEVELP(I) - IPOOL(I)
      IF(L.LE.N) GO TO 2577
      K = I
      N = L
 2577 CONTINUE
      IF(K.EQ.0) GO TO 2588
      CALL CARRY(K)
      IF(K.EQ.999) RETURN
      GO TO 2566
C
C     IS A HEAT CURRENTLY BEING UNLOADED, IF NOT, ARE THERE HEATS QUED
C        IN THE RAILROAD CARS WAITING TO BE UNLOADED
C
 2588 IF(MATUNL.NE.0) GO TO 2666
      N = 0
      DO 2599 I=1,MAXTYP
      N = N + INVQT(I)
 2599 MASK(I) = 0
      IF(N.EQ.0) GO TO 2711
C
C     SELECT THE TYPE OF MATERIAL (5 1/4, 6, 7 3/8) TO UNLOAD, DEPENDING
C        ON QUE LENGTH AND PROVIDING THERE IS ROOM TO UNLOAD IT
C
 2600 N = 0
      DO 2611 I=1,MAXTYP
      IF(MASK(I).NE.0) GO TO 2611
      IF(N.GE.INVQT(I)) GO TO 2611
      N = INVQT(I)
      MATUNL = I
 2611 CONTINUE
      IF(N.EQ.0) GO TO 2711
C
C     SELECT THE BAY TO UNLOAD INTO IF IT HAS ENOUGH ROOM AND IT IS NOT
C        CURRENTLY SUPPLYING A FEEDER
C
      K = 9999
      DO 2622 I=1,MAXBAY
```

```
0069           IF(I.EQ.IFEED(MATUNL)) GO TO 2622
0070           J = IBAYP(I,MATUNL)
0071           IF(J.LE.0.OR.J.GT.K) GO TO 2622
0072           IF(INVQ(MATUNL,1)+INVBT(I).GT.MXINVB(I)) GO TO 2622
0073           K = J
0074           IPTBAY = I
0075      2622 CONTINUE
         C
         C     ARE THE BAYS WHICH HOLD THIS TYPE OF MATERIAL FULL, IF YES, MASK
         C        THIS MATERIAL FROM FURTHER UNLOADING CONSIDERATION AND THEN GO
         C        BACK TO SELECT UNLOADING ANOTHER TYPE OF MATERIAL
         C
0076           IF(K.NE.9999) GO TO 2633
0077           MASK(MATUNL) = 1
0078           IPTBAY = 0
0079           MATUNL = 0
0080           ITOP = 0
0081           GO TO 2600
         C
         C     RECORD BAY USAGE AND FIND TOP OF THE PILE IN TERMS OF HEATS
         C
0082      2633 IUSE(IPTBAY) = IUSE(IPTBAY) + 1
0083           DO 2644 J=1,MAXHET
0084           ITOP = J
0085           IF(INVB(IPTBAY,J).EQ.0) GO TO 2666
0086      2644 CONTINUE
0087           CALL ERROR (2655)
0088           RETURN
         C
         C     GENERATE THE NUMBER OF BILLETS ON THIS CAR AND IT'S LOCATION
         C
0089      2666 IF(NCAR.GT.0) GO TO 2677
0090           CALL GEN(MATUNL+38)
0091           NCAR = X + 0.5
0092           IF(INVQ(MATUNL,1).LT.NCAR) NCAR = INVQ(MATUNL,1)
0093           CALL GEN (14)
0094           Z = X
0095           CALL RANDOM
0096           IF(X.LT.0.5) Z = -Z
0097           XCAR = XBAY(IPTBAY) + Z
         C
         C     COMPUTE THE TRAVEL TIME TO THE RAILROAD CAR AND CHECK TO SEE IF AN
         C        INDEPENDENT EVENT HAS OCCURRED
         C
0098      2677 XDIS = ABS(XNOW - XCAR)
0099           YDIS = ABS(YNOW - YCENTR)
0100           CALL TRPREP(XDIS,YDIS)
0101           XNOW = XCAR
0102           YNOW = YCENTR
0103           IF(CLOCK.GE.TNEXT) GO TO 2722
         C
         C     GENERATE A PICK, TRANSFER, SWING AND LASTLY A SET DOWN TIME
         C
```

```
0104          CALL GEN(11)
0105          NTIME(3) = NTIME(3) + 1
0106          STIME(3) = STIME(3) + X
0107          IF(X.LT.SMIN(3)) SMIN(3) = X
0108          IF(X.GT.SMAX(3)) SMAX(3) = X
0109          CALL SNAP
0110          XDIS = ABS(XNOW - XBAY(IPTBAY))
0111          YDIS = ABS(YNOW - YBAY(IPTBAY))
0112          CALL TRPREP(XDIS,YDIS)
0113          XNOW = XBAY(IPTBAY)
0114          YNOW = YBAY(IPTBAY)
0115          CALL GEN(12)
0116          NTIME(6) = NTIME(6) + 1
0117          STIME(6) = STIME(6) + X
0118          IF(X.LT.SMIN(6)) SMIN(6) = X
0119          IF(X.GT.SMAX(6)) SMAX(6) = X
0120          CALL SNAP
0121          CALL GEN(13)
0122          NTIME(4) = NTIME(4) + 1
0123          STIME(4) = STIME(4) + X
0124          IF(X.LT.SMIN(4)) SMIN(4) = X
0125          IF(X.GT.SMAX(4)) SMAX(4) = X
0126          CALL SNAP
        C
        C     GENERATE THE NO. OF BILLETS PICKED OUT OF THE CAR, DECREASE THE
        C        CAR AND QUE INVENTORY AND INCREASE THE BAY INVENTORY BY THE
        C        PICK LOAD, IF AN INDEPENDENT EVENT HAS NOT OCCURRED, RETURN TO
        C        PICK UP ANOTHER LOAD OUT OF THE RAILROAD CAR
        C
0127          CALL GEN(MATUNL+14)
0128          I = X + 0.5
0129          J = NCAR - I
0130          IF(J.LT.0) I = NCAR
0131          NCAR = NCAR - I
0132          INVB(IPTBAY,ITOP) = INVB(IPTBAY,ITOP) + I
0133          INVBT(IPTBAY) = INVBT(IPTBAY) + I
0134          INVQ(MATUNL,1) = INVQ(MATUNL,1) - I
0135          INVQT(MATUNL) = INVQT(MATUNL) - I
0136          IF(INVQ(MATUNL,1).EQ.0) GO TO 2688
0137          IF(CLOCK.GE.TNEXT) GO TO 2722
0138          GO TO 2666
        C
        C     THE HEAT BEING UNLOADED IS NOW COMPLETELY UNLOADED, RESTACK THE
        C        CAR QUE, ZERO THE BAY AND MATERIAL UNLOAD POINTERS
        C
0139     2688 DO 2699 L=2,MAXQUE
0140          INVQ(MATUNL,L-1) = INVQ(MATUNL,L)
0141          IF(INVQ(MATUNL,L).EQ.0) GO TO 2700
0142     2699 CONTINUE
0143          INVQ(MATUNL,MAXQUE) = 0
0144     2700 IPTBAY = 0
0145          MATUNL = 0
0146          ITOP = 0
```

```
0147          GO TO 2566
        C
        C     SLACK HAS OCCURRED (THE CRANE HAS NOTHING TO DO FOR AWHILE) COM-
        C        PUTE AND RECORD THE LENGTH OF THIS REST PERIOD
        C
0148     2711 X = TNEXT - CLOCK
0149          NTIME(2) = NTIME(2) + 1
0150          STIME(2) = STIME(2) + X
0151          IF(X.LT.SMIN(2)) SMIN(2) = X
0152          IF(X.GT.SMAX(2)) SMAX(2) = X
0153          CALL SNAP
        C
        C     IT IS TIME TO PROCESS AN INDEPENDENT EVENT.  COMPUTE & RECORD THE
        C        AMOUNT OF WAIT TIME
        C
0154     2722 RESUP = 0.0
0155          STARTE = CLOCK
0156          WAITT = STARTE - TNEXT
0157          IF(WAITT.LE.0.0) GO TO 2733
0158          IF(WAITT.LT.WMIN) WMIN = WAITT
0159          IF(WAITT.GT.WMAX) WMAX = WAITT
0160          WAIT = WAIT + WAITT
0161          NWAIT = NWAIT + 1
        C
        C     IF THE CURRENT EVENT IS A FEEDER CALL CHECK TO SEE IF THERE IS
        C        ENOUGH BILLETS IN THE WORK AREA FOR 1 CHARGE, IF NOT HAUL SOME
        C
0162     2733 IF(IVENT.GT.3) GO TO 2799
0163     2744 IF(IPOOL(IVENT).GE.NCHAR(IVENT)) GO TO 2755
0164          K = IVENT
0165          CALL CARRY(K)
0166          IF(K.EQ.999) RETURN
0167          NGET = NGET + 1
0168          GO TO 2744
0169     2755 K = 0
        C
        C     TRAVEL TO THE WORK AREA
        C
0170     2766 XDIS = ABS(XNOW - XWORK(IVENT))
0171          YDIS = ABS(YNOW - YWORK(IVENT))
0172          CALL TRPREP(XDIS,YDIS)
0173          XNOW = XWORK(IVENT)
0174          YNOW = YWORK(IVENT)
        C
        C     PICK UP A CHARGE OR A PORTION OF A CHARGE
        C
0175          CALL GEN(27)
0176          NTIME(3) = NTIME(3) + 1
0177          STIME(3) = STIME(3) + X
0178          IF(X.LT.SMIN(3)) SMIN(3) = X
0179          IF(X.GT.SMAX(3)) SMAX(3) = X
0180          CALL SNAP
        C
```

```
              C      TRAVEL TO THE FEED TABLE                                      GLM 8760
              C                                                                    GLM 8770
 0181                XDIS = ABS(XNOW - XFEED(IVENT))                               GLM 8780
 0182                YDIS = ABS(YNOW - YFEED(IVENT))                               GLM 8790
 0183                CALL TRPREP(XDIS,YDIS)                                        GLM 8800
 0184                XNOW = XFEED(IVENT)                                           GLM 8810
 0185                YNOW = YFEED(IVENT)                                           GLM 8820
              C                                                                    GLM 8830
              C      SET THE CHARGE OR PORTION OF THE CHARGE ON THE FEED TABLE     GLM 8840
              C                                                                    GLM 8850
 0186                CALL GEN(28)                                                  GLM 8860
 0187                NTIME(4) = NTIME(4) + 1                                       GLM 8870
 0188                STIME(4) = STIME(4) + X                                       GLM 8880
 0189                IF(X.LT.SMIN(4)) SMIN(4) = X                                  GLM 8890
 0190                IF(X.GT.SMAX(4)) SMAX(4) = X                                  GLM 8900
              C                                                                    GLM 8910
              C      RECORD THE NO. BILLETS TAKEN OUT OF THE POOL AND DETERMINE IF THE GLM 8920
              C         CHARGE HAS BEEN COMPLETELY LOADED                          GLM 8930
              C                                                                    GLM 8940
 0191                L = NFEED(IVENT)                                              GLM 8950
 0192                J = K + L                                                     GLM 8960
 0193                IF(J.GT.NCHAR(IVENT)) L = NCHAR(IVENT) - K                    GLM 8970
 0194                IPOOL(IVENT) = IPOOL(IVENT) - L                               GLM 8980
 0195                CALL SNAP                                                     GLM 8990
              C                                                                    GLM 9000
              C      IF FIRST LOAD OF THE CHARGE, RECORD AMOUNT OF WAIT TIME       GLM 9010
              C                                                                    GLM 9020
 0196                IF(K.GT.0) GO TO 2788                                         GLM 9030
 0197                RESUP = CLOCK - TNEXT                                         GLM 9040
 0198                N = IVENT + 7                                                 GLM 9050
 0199                NTIME(N) = NTIME(N) + 1                                       GLM 9060
 0200                STIME(N) = STIME(N) + RESUP                                   GLM 9070
 0201                IF(RESUP.LT.SMIN(N)) SMIN(N) = RESUP                          GLM 9080
 0202                IF(RESUP.GT.SMAX(N)) SMAX(N) = RESUP                          GLM 9090
 0203                NCOUNT = NCOUNT + 1                                           GLM 9100
 0204                WRITE (IWF3) N, RESUP                                         GLM 9110
 0205                IF(RESUP.LE.WAITMX) GO TO 2788                                GLM 9120
 0206                CALL ERROR (2777)                                             GLM 9130
 0207                RETURN                                                        GLM 9140
 0208          2788  K = K + L                                                     GLM 9150
 0209                IF(K - NCHAR(IVENT))2766,2855,2855                            GLM 9160
              C                                                                    GLM 9170
              C      IF THE CURRENT EVENT IS AN ARRIVAL OF A HEAT, GENERATE THE SIZE OFGLM 9180
              C         THE HEAT, STORE THIS IN THE HEAT QUE                       GLM 9190
              C                                                                    GLM 9200
 0210          2799  IF(IVENT.GT.6) GO TO 2833                                     GLM 9210
 0211                K = IVENT - 3                                                 GLM 9220
 0212                DO 2800 L=1,MAXQUE                                            GLM 9230
 0213                M = L                                                         GLM 9240
 0214                IF(INVQ(K,L).EQ.0) GO TO 2822                                 GLM 9250
 0215          2800  CONTINUE                                                      GLM 9260
 0216                CALL ERROR (2811)                                             GLM 9270
 0217                RETURN                                                        GLM 9280
```

```
 2822 CALL GEN(K+35)
      I = X + 0.5
      INVQ(K,M) = I
      INVQT(K) = INVQT(K) + I
      GO TO 2855
C
C     IF THE CURRENT EVENT IS A BREAK, GENERATE THE LENGTH OF THIS BREAK
C        RECORD IT. SLIP THE FEEDER CALLS BY THIS TIME AND GENERATE THE
C        NEXT TIME THIS EVENT WILL NEXT OCCUR AND TAKE INVENTORY
C
 2833 Y = 0.0
      IF(IVENT.GT.10) GO TO 2866
      CALL GEN(IVENT+11)
      NTIME(7) = NTIME(7) + 1
      STIME(7) = STIME(7) + X
      IF(X.LT.SMIN(7)) SMIN(7) = X
      IF(X.GT.SMAX(7)) SMAX(7) = X
      DO 2844 I=1,3
 2844 ETIME(I) = ETIME(I) + X
      CALL SNAP
 2855 CALL GEN(IVENT)
      Y = TNEXT + X
 2866 INVTAL = INVTAL + 1
      DO 2888 J=1,MAXTYP
      K = 0
      DO 2877 I=1,MAXBAY
 2877 IF(IBAYP(I,J).GT.0) K = K + INVBT(I)
      MASK(J) = K + INVQT(J) + IPOOL(J)
      IF(MASK(J).LT.MININV(J)) MININV(J) = MASK(J)
      IF(MASK(J).GT.MAXINV(J)) MAXINV(J) = MASK(J)
 2888 AVEINV(J) = AVEINV(J) + MASK(J)
C
C     IS THIS TIME SEGMENT IS WANTED FOR REVIEW?
C
      IF(CLOCK.LT.TSTART.OR.CLOCK.GT.TSTOP) GO TO 2933
      ICOUNT = ICOUNT + 1
      IF(IPS1.NE.0) GO TO 2922
      I = 0
      J = 0
      K = 0
      IF(IFEED(1).GT.0) I = INVB(IFEED(1),IBTOP(1))
      IF(IFEED(2).GT.0) J = INVB(IFEED(2),IBTOP(2))
      IF(IFEED(3).GT.0) K = INVB(IFEED(3),IBTOP(3))
      IF(LINE.LT.50) GO TO 2900
      WRITE (IOUT,2899) IPAGE
 28990FORMAT (1H1, 50X, 19HEVENT AND INVENTORY, 49X, 6HPAGE =, I4/ 9H0
     1REF EV, 5X, 5HREADY, 5X, 5HSTART, 2X, 4HWAIT, 2X, 2HDO, 3X,
     25HRESUP, 4X, 6HFINISH, 5X, 4HNEXT, 1X, 15HTOTAL INVENTORY, 1X,
     310HBILLETS IN, 2X, 11HBILLET LEFT, 2X, 6HFEEDER, 3X,10HUNLOAD QUE,
     41X, 3HREC/ 9H    NO NO, 5X, 4HTIME, 6X, 4HTIME, 3X, 4HTIME, 2X,
     54HTIME, 2X, 4HTIME, 6X, 4HTIME, 5X, 4HTIME, 1X,15H5 1/4   6   7 3/8,
     62X, 9HWORK POOL, 2X, 11HSUPPLY HEAT, 1X, 8HSUPPLIER, 2X,
     710HNO BILLETS, 1X, 3HBAY)
```

```
 0256             IPAGE = IPAGE + 1                                              GLM 9820
 0257             LINE = 0                                                       GLM 9830
 0258        2900 LINE = LINE + 1                                                GLM 9840
 0259             X = CLOCK - STARTE                                             GLM 9850
 0260            0WRITE (IOUT,2911) ICOUNT, IVENT, TNEXT, STARTE, WAITT, X, RESUP,  GLM 9860
                 1CLOCK, Y, MASK, IPOOL, I, J, K, IFEED, INVQT, IPTBAY           GLM 9870
 0261        2911 FORMAT (1H , I5, I3, 2F10.2, 3F6.2, 2F10.2, 3I5, 6I4, 3I3, 4I4)  GLM 9880
 0262        2922 WRITE (IWF2) INVBT,STIME,XTRAV,YTRAV,XTIME,YTIME,NTIME,ITRAV,JTRAVGLM 9890
 0263        2933 IF(IVENT.EQ.11) RETURN                                         GLM 9900
 0264             ETIME(IVENT) = Y                                               GLM 9910
 0265             GO TO 2544                                                     GLM 9920
 0266             END                                                            GLM 9930
```

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0001              SUBROUTINE CARRY(M)                                               GLM 9940
0002             0COMMON CLOCK, SETUP, TNEXT, XNOW, YNOW, XTRAV, YTRAV, XTIME,YTIME,GLM 9950
                 1YCENTR, SMSTOP, TLOOK, CLAST, TSTART, TSTOP, X, Y, Z, INPT, IOUT, GLM 9960
                 2IPNH, IWF1, IWF2, IWF3, MAXBAY, MAXSTO, MAXKEY, MAXTYP, MAXEVT,   GLM 9970
                 3MAXQUE, MAXHET, IPS1, IPS2, IPS3, IPS4, IPS5, IPS6, IVENT, ISEED, GLM 9980
                 4IRROR, LOOK, ICOUNT, ISAVE, MATUNL, IPTBAY, ITOP, INVTAL, ITRAV,  GLM 9990
                 5JTRAV, WAIT, NWAIT, WMIN, WMAX, NGET, NCOUNT                      GLM10000
0003             0COMMON/STO/STORE( 300), KEY(50), ETIME(10), IBAYP(36,3), XBAY(36),GLM10010
                 1YBAY(36), INVB(36,6), MXINVB(36), INVBT(36), IUSE(36), INVQ(3,20),GLM10020
                 2INVQT(3),IPOOL(3),LEVELP(3),IFEED(3),IBTOP(3),NCHAR(3),NFEED(3),  GLM10030
                 3MASK(3), XFEED(3), YFEED(3), XWORK(3), YWORK(3), MININV(3),       GLM10040
                 4MAXINV(3), AVEINV(3), NTIME(10), STIME(10), SMIN(10), SMAX(10)    GLM10050
            C                                                                       GLM10060
            C     THE FUNCTION OF THIS SUBROUTINE IS THAT OF MODELING THE TRANSPORT-GLM10070
            C        ING OF ONE LOAD OF BILLETS FROM A BAY TO THE WORK AREA         GLM10080
            C        FIRST, DETERMINE WHICH BAY TO DRAW STOCK FROM, IF BETWEEN HEATSGLM10090
            C                                                                       GLM10100
0004              L = IFEED(M)                                                      GLM10110
0005              J = IBTOP(M)                                                      GLM10120
0006              IF(L.NE.0) GO TO 2999                                             GLM10130
0007              K = 9999                                                          GLM10140
0008              DO 2944 I=1,MAXBAY                                                GLM10150
0009              IF(I.EQ.IPTBAY) GO TO 2944                                        GLM10160
0010              J = IBAYP(I,M)                                                    GLM10170
0011              IF(J.LE.0.OR.J.GT.K) GO TO 2944                                   GLM10180
0012              IF(INVB(I,1).LE.0) GO TO 2944                                     GLM10190
0013              K = J                                                             GLM10200
0014              L = I                                                             GLM10210
0015         2944 CONTINUE                                                          GLM10220
0016              IF(K.NE.9999) GO TO 2966                                          GLM10230
0017              CALL ERROR (2955)                                                 GLM10240
0018              IRROR = IRROR - 1                                                 GLM10250
0019              CALL ERROR (M)                                                    GLM10260
0020              M = 999                                                           GLM10270
0021              RETURN                                                            GLM10275
            C                                                                       GLM10280
            C     RECORD BAY USAGE AND LOAD THE TOP OF PILE AND BAY POINTERS        GLM10290
            C                                                                       GLM10295
0022         2966 IUSE(L) = IUSE(L) + 1                                             GLM10300
0023              DO 2977 I=1,MAXHET                                                GLM10310
0024              J = MAXHET + 1 - I                                                GLM10320
0025              IF(INVB(L,J).NE.0) GO TO 2988                                     GLM10330
0026         2977 CONTINUE                                                          GLM10340
0027         2988 IBTOP(M) = J                                                      GLM10350
0028              IFEED(M) = L                                                      GLM10360
            C                                                                       GLM10370
            C     GENERATE TRAVEL TO BAY AND PICK TIME                              GLM10380
            C                                                                       GLM10390
0029         2999 XDIS = ABS(XNOW - XBAY(L))                                        GLM10400
0030              YDIS = ABS(YNOW - YBAY(L))                                        GLM10410
0031              CALL TRPREP(XDIS,YDIS)                                            GLM10420
0032              XNOW = YBAY(L)                                                    GLM10430
0033              YNOW = YBAY(L)                                                    GLM10440
```

```
      CALL GEN(22)
      NTIME(3) = NTIME(3) + 1
      STIME(3) = STIME(3) + X
      IF(X.LT.SMIN(3)) SMIN(3) = X
      IF(X.GT.SMAX(3)) SMAX(3) = X
      CALL SNAP
C
C     GENERATE THE TIME TO TRAVEL TO THE WORK AREA, SET UNSQUARED LOAD
C        DOWN TIME AND THE NUMBER OF BILLETS MOVED
C
      XDIS = ABS(XNOW - XWORK(M))
      YDIS = ABS(YNOW - YWORK(M))
      CALL TRPREP(XDIS,YDIS)
      XNOW = XWORK(M)
      YNOW = YWORK(M)
      CALL GEN(26)
      NTIME(4) = NTIME(4) + 1
      STIME(4) = STIME(4) + X
      IF(X.LT.SMIN(4)) SMIN(4) = X
      IF(X.GT.SMAX(4)) SMAX(4) = X
      CALL SNAP
      CALL GEN(M+22)
      I = X + 0.5
      IF(INVB(L,J).GT.I) GO TO 3000
      I = INVB(L,J)
      IFEED(M) = 0
      IBTOP(M) = 0
 3000 INVB(L,J) = INVB(L,J) - I
      INVBT(L) = INVBT(L) - I
      IPOOL(M) = IPOOL(M) + I
C
C     GENERATE THE TIME REQUIRED TO SQUARE UP THIS NEW LOAD
C
      CALL GEN(29)
      NTIME(5) = NTIME(5) + 1
      STIME(5) = STIME(5) + X
      IF(X.LT.SMIN(5)) SMIN(5) = X
      IF(X.GT.SMAX(5)) SMAX(5) = X
      CALL SNAP
      RETURN
      END
```

```
0001       SUBROUTINE TRPREP(XDIS,YDIS)
0002      0COMMON CLOCK, SETUP, TNEXT, XNOW, YNOW, XTRAV, YTRAV, XTIME,YTIME,
          1YCENTR, SMSTOP, TLOOK, CLAST, TSTART, TSTOP, X, Y, Z, INPT, IOUT,
          2IPNH, IWF1, IWF2, IWF3, MAXBAY, MAXSTO, MAXKEY, MAXTYP, MAXEVT,
          3MAXQUE, MAXHET, IPS1, IPS2, IPS3, IPS4, IPS5, IPS6, IVENT, ISEED,
          4IRROR, LOOK, ICOUNT, ISAVE, MATUNL, IPTBAY, ITOP, INVTAL, ITRAV,
          5JTRAV, WAIT, NWAIT, WMIN, WMAX, NGET, NCOUNT
0003      0COMMON/STO/STORE( 300), KEY(50), ETIME(10), IBAYP(36,3), XBAY(36),
          1YBAY(36), INVB(36,6), MXINVB(36), INVBT(36), IUSE(36), INVQ(3,20),
          2INVQT(3),IPOOL(3),LEVELP(3),IFEED(3),IBTOP(3),NCHAR(3),NFEED(3),
          3MASK(3), XFEED(3), YFEED(3), XWORK(3), YWORK(3), MININV(3),
          4MAXINV(3), AVEINV(3), NTIME(10), STIME(10), SMIN(10), SMAX(10)
      C
      C     THIS SUBROUTINE PREPARES DATA FOR COMPUTING X AND Y TRAVEL TIME
      C        FIRST, COMPUTE THE X TRAVEL TIME
      C
0004        Z = 0.0
0005        IF(XDIS.EQ.0.0) GO TO 3011
0006        ITRAV = ITRAV + 1
0007        XTRAV = XTRAV + XDIS
0008        CALL GEN(30)
0009        ACC = X
0010        CALL GEN(31)
0011        DCC = X
0012        CALL GEN(32)
0013        VTOP = X/60.0
0014        CALL TRTIME (T,XDIS,ACC,DCC,VTOP)
0015        XTIME = XTIME + T
0016        Z = T
      C
      C     COMPUTE THE Y TRAVEL TIME
      C
0017   3011 T = 0.0
0018        IF(YDIS.EQ.0.0) GO TO 3022
0019        JTRAV = JTRAV + 1
0020        YTRAV = YTRAV + YDIS
0021        CALL GEN(33)
0022        ACC = X
0023        CALL GEN(34)
0024        DCC = X
0025        CALL GEN(35)
0026        VTOP = X/60.0
0027        CALL TRTIME (T,YDIS,ACC,DCC,VTOP)
0028        YTIME = YTIME + T
0029   3022 IF(T.GT.Z) Z = T
0030        X = Z
0031        IF(X.EQ.0.0) RETURN
0032        NTIME(1) = NTIME(1) + 1
0033        STIME(1) = STIME(1) + X
0034        IF(X.LT.SMIN(1)) SMIN(1) = X
0035        IF(X.GT.SMAX(1)) SMAX(1) = X
0036        CALL SNAP
0037        RETURN
0038        END
```

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0001               SUBROUTINE TRTIME (T,DIS,ACC,DCC,VTOP)                                     GLM11400
             C                                                                                GLM11410
             C     THIS SUBROUTINE COMPUTES TRAVEL TIME, FIRST TASK IS TO COMPUTE             GLM11420
             C        THE ACCELERATION AND DECELERATION DISTANCES                             GLM11430
             C                                                                                GLM11440
0002               VTOPSQ = VTOP*VTOP                                                         GLM11450
0003               ADIS = VTOPSQ/(2.0*ACC)                                                    GLM11460
0004               DDIS = VTOPSQ/(2.0*DCC)                                                    GLM11470
0005               R = DIS - (ADIS + DDIS)                                                    GLM11480
             C                                                                                GLM11490
             C     IF THE SUM OF THE ACCELERATION AND DECELERATION DISTANCE IS LESS           GLM11500
             C        THAN THE TOTAL TRAVEL DISTANCE, COMPUTE THE TIME OF TRAVEL IN           GLM11510
             C        THE 3 SEGMENTS OF ACCELERATION, CONSTANT SPEED, DECELERATION            GLM11520
             C                                                                                GLM11530
0006               IF(R.LT.0.0) GO TO 3033                                                    GLM11540
0007               T = SQRT((2.0*ADIS)/ACC) + R/VTOP + SQRT((2.0*DDIS)/DCC)                   GLM11550
0008               GO TO 3044                                                                 GLM11560
             C                                                                                GLM11570
             C     TOP VELOCITY CANNOT BE OBTAINED, COMPUTE ACCELERATION AND DECEL-           GLM11580
             C        ERATION TIME BY FINDING THE TRANSFER VELOCITY                           GLM11590
             C                                                                                GLM11600
0009          3033 R = DCC/ACC                                                                GLM11610
0010               T = SQRT((2.0*DIS)/(DCC*(1.0 + R)))                                        GLM11620
0011               T = R*T + T                                                                GLM11630
0012          3044 T = T/60.0                                                                 GLM11640
0013               RETURN                                                                     GLM11650
0014               END                                                                        GLM11660
```

```
0001        SUBROUTINE SNAP                                                GLM11670
0002       0COMMON CLOCK, SETUP, TNEXT, XNOW, YNOW, XTRAV, YTRAV, XTIME,YTIME,GLM11680
           1YCENTR, SMSTOP, TLOOK, CLAST, TSTART, TSTOP, X, Y, Z, INPT, IOUT, GLM11690
           2IPNH, IWF1, IWF2, IWF3, MAXBAY, MAXSTO, MAXKEY, MAXTYP, MAXEVT,   GLM11700
           3MAXQUE, MAXHET, IPS1, IPS2, IPS3, IPS4, IPS5, IPS6, IVENT, ISEED, GLM11710
           4IRROR, LOOK, ICOUNT, ISAVE, MATUNL, IPTBAY, ITOP, INVTAL, ITRAV,  GLM11720
           5JTRAV, WAIT, NWAIT, WMIN, WMAX, NGET, NCOUNT                      GLM11730
0003       0COMMON/STO/STORE( 300), KEY(50), ETIME(10), IBAYP(36,3), XBAY(36),GLM11740
           1YBAY(36), INVB(36,6), MXINVB(36), INVBT(36), IUSE(36), INVQ(3,20),GLM11750
           2INVQT(3),IPOOL(3),LEVELP(3),IFEED(3),IBTOP(3),NCHAR(3),NFEED(3),  GLM11760
           3MASK(3), XFEED(3), YFEED(3), XWORK(3), YWORK(3), MININV(3),       GLM11770
           4MAXINV(3), AVEINV(3), NTIME(10), STIME(10), SMIN(10), SMAX(10)    GLM11780
      C                                                                     GLM11790
      C     THIS SUBROUTINE TAKES A PERIODIC SNAPSHOT OF KEY PARAMETERS OF THEGLM11800
      C        SYSTEM TLOOK TIME UNITS APART                                GLM11810
      C                                                                     GLM11820
0004        CLOCK = CLOCK + X                                               GLM11830
0005        IF(IPS6.NE.0) RETURN                                            GLM11840
0006        X = CLOCK - CLAST                                               GLM11850
0007        IF(X.LT.TLOOK) RETURN                                           GLM11860
0008        J = X/TLOOK                                                     GLM11870
0009        DO 3055 I=1,J                                                   GLM11880
0010        LOOK = LOOK + 1                                                 GLM11890
0011        CLAST = CLAST + TLOOK                                           GLM11900
0012   3055 WRITE (IWF1) CLAST, INVBT, INVQT, IPOOL                         GLM11910
0013        RETURN                                                          GLM11920
0014        END                                                             GLM11930
```

```
 0001             SUBROUTINE RANDOM                                                  GLM11940
 0002            0COMMON CLOCK, SETUP, TNEXT, XNOW, YNOW, XTRAV, YTRAV, XTIME,YTIME,GLM11950
                 1YCENTR, SMSTOP, TLOOK, CLAST, TSTART, TSTOP, X, Y, Z, INPT, IOUT,  GLM11960
                 2IPNH, IWF1, IWF2, IWF3, MAXBAY, MAXSTO, MAXKEY, MAXTYP, MAXEVT,    GLM11970
                 3MAXQUE, MAXHET, IPS1, IPS2, IPS3, IPS4, IPS5, IPS6, IVENT, ISEED,  GLM11980
                 4IRROR, LOOK, ICOUNT, ISAVE, MATUNL, IPTBAY, ITOP, INVTAL, ITRAV,   GLM11990
                 5JTRAV, WAIT, NWAIT, WMIN, WMAX, NGET, NCOUNT                       GLM12000
            C                                                                        GLM12010
            C     THIS SUBROUTINE GENERATES UNIFORM DEVIATES ON AN IBM 360 MACHINE  GLM12020
            C        IN THE EVENT THIS PROGRAM IS PUT ON SOMETHING OTHER THAN 360   GLM12030
            C        GEAR, ANOTHER UNIFORM GENERATOR MAY BE REQUIRED.  ISEED CARRIESGLM12040
            C        THE SEED UTILIZED TO MAINTAIN AND CREATE NEW UNIFORM DEVIATES. GLM12050
            C        X CARRIES THE UNIFORM DEVIATE.  (THIS IS IBM'S RANDU.)         GLM12060
            C                                                                        GLM12070
 0003             ISEED = ISEED*65539                                                GLM12080
 0004             IF(ISEED)3066,3077,3077                                            GLM12090
 0005        3066 ISEED = ISEED + 2147483647 + 1                                     GLM12100
 0006        3077 X = ISEED                                                          GLM12110
 0007             X = X*.4656613E-9                                                  GLM12120
 0008             RETURN                                                             GLM12130
 0009             END                                                                GLM12140
```

```
0001           SUBROUTINE GEN(IGEN)
0002          0COMMON CLOCK, SETUP, TNEXT, XNOW, YNOW, XTRAV, YTRAV, XTIME,YTIME,
              1YCENTR, SMSTOP, TLOOK, CLAST, TSTART, TSTOP, X, Y, Z, INPT, IOUT,
              2IPNH, IWF1, IWF2, IWF3, MAXBAY, MAXSTO, MAXKEY, MAXTYP, MAXEVT,
              3MAXQUE, MAXHET, IPS1, IPS2, IPS3, IPS4, IPS5, IPS6, IVENT, ISEED,
              4IRROR, LOOK, ICOUNT, ISAVE, MATUNL, IPTBAY, ITOP, INVTAL, ITRAV,
              5JTRAV, WAIT, NWAIT, WMIN, WMAX, NGET, NCOUNT
0003          0COMMON/STO/STORE( 300), KEY(50), ETIME(10), IBAYP(36,3), XBAY(36),
              1YBAY(36), INVB(36,6), MXINVB(36), INVBT(36), IUSE(36), INVQ(3,20),
              2INVQT(3),IPOOL(3),LEVELP(3),IFEED(3),IBTOP(3),NCHAR(3),NFEED(3),
              3MASK(3), XFEED(3), YFEED(3), XWORK(3), YWORK(3), MININV(3),
              4MAXINV(3), AVEINV(3), NTIME(10), STIME(10), SMIN(10), SMAX(10)
         C
         C     THIS SUBROUTINE GENERATES RANDOM VARIATES
         C
0004           I = KEY(IGEN)
0005           M = STORE(I)
0006           I1 = I + 1
0007           I2 = I + 2
0008           I3 = I + 3
0009           I4 = I + 4
0010          0GO TO (3144,3155,3166,3199,3199,3200,3222,3200,3233,3255,3266,
              13200,3300,3322,3088),M
         C
         C     CREATE A VARIATE FROM A DISTRIBUTION ENTERED AS A HISTOGRAM
         C
0011      3088 DO 3099 M=I2,MAXSTO
0012           IF(STORE(M).EQ.-999.0) GO TO 3100
0013      3099 I3 = M - 1
0014      3100 CALL RANDOM
0015           PROB1 = 0.0
0016           DO 3111 L=I2,I3,2
0017           M = L
0018           PROB2 = PROB1 + STORE(M)
0019           IF(X.LE.PROB2) GO TO 3122
0020      3111 PROB1 = PROB2
0021           GO TO 3133
0022      3122 PROB1 = (X - PROB1)/(PROB2 - PROB1)
0023      3133 X = STORE(M-1) + (STORE(M+1) - STORE(M-1))*PROB1
0024           GO TO 3377
         C
         C     CREATE A CONSTANT VARIATE
         C
0025      3144 X = STORE(I1)
0026           GO TO 3377
         C
         C     CREATE A UNIFORM VARIATE
         C
0027      3155 CALL RANDOM
0028           X = STORE(I1) + (STORE(I2) - STORE(I1))*X
0029           GO TO 3377
         C
         C     CREATE A TRIANGULAR VARIATE
```

```
                C                                                                        GLM12680
  0030           3166 PROB1 = STORE(I2) - STORE(I1)                                      GLM12690
  0031                Y = (STORE(I3) - STORE(I1))/PROB1                                  GLM12700
  0032                CALL RANDOM                                                        GLM12710
  0033                IF(X.GT.Y) GO TO 3177                                              GLM12720
  0034                Y = SQRT(X*Y)                                                      GLM12730
  0035                GO TO 3188                                                         GLM12740
  0036           3177 Y = 1.0 - SQRT(1.0 - Y - X + X*Y)                                  GLM12750
  0037           3188 X = STORE(I1) + Y*PROB1                                            GLM12760
  0038                GO TO 3377                                                         GLM12770
                C                                                                        GLM12780
                C     CREATE A NORMAL OR LOGNORMAL-(M.EQ.5) VARIATE                      GLM12790
                C                                                                        GLM12800
  0039           3199 CALL NORM                                                          GLM12810
  0040                X = X*STORE(I4) + STORE(I3)                                        GLM12820
  0041                IF(M.EQ.5) X = EXP(X)                                              GLM12830
  0042                GO TO 3366                                                         GLM12840
                C                                                                        GLM12850
                C     CREATE A GAMMA(M.EQ.6), ERLANG(M.EQ.8) OR PASCAL(M.EQ.12)          GLM12860
                C                                                                        GLM12870
  0043           3200 ISAVE = STORE(I4) + 0.001                                          GLM12880
  0044                IF(M.GT.6) GO TO 3211                                              GLM12890
  0045                Y = ISAVE                                                          GLM12900
  0046                Y = STORE(I4) - Y                                                  GLM12910
  0047                CALL RANDOM                                                        GLM12920
  0048                IF(X.GT.Y) GO TO 3211                                              GLM12930
  0049                ISAVE = ISAVE + 1                                                  GLM12940
  0050           3211 CALL GAM                                                           GLM12950
  0051                X = Y/STORE(I3)                                                    GLM12960
  0052                IF(M.EQ.12) GO TO 3299                                             GLM12970
  0053                GO TO 3366                                                         GLM12980
                C                                                                        GLM12990
                C     CREATE A WEIBULL VARIATE                                           GLM13000
                C                                                                        GLM13010
  0054           3222 CALL RANDOM                                                        GLM13020
  0055                X = STORE(I1) + STORE(I3)*((-ALOG(X))**STORE(I4))                  GLM13030
  0056                GO TO 3366                                                         GLM13040
                C                                                                        GLM13050
                C     CREATE A CHI SQUARE VARIATE                                        GLM13060
                C                                                                        GLM13070
  0057           3233 PROB1 = 0.0                                                        GLM13080
  0058                IF(STORE(I3).GT.0.0) GO TO 3244                                    GLM13090
  0059                CALL NORM                                                          GLM13100
  0060                PROB1 = X*X                                                        GLM13110
  0061           3244 ISAVE = ABS(STORE(I3)) + 0.001                                     GLM13120
  0062                CALL GAM                                                           GLM13130
  0063                X = Y/0.5 + PROB1                                                  GLM13140
  0064                GO TO 3366                                                         GLM13150
                C                                                                        GLM13160
                C     CREATE A BETA VARIATE                                              GLM13170
                C                                                                        GLM13180
  0065           3255 ISAVE = STORE(I3) + 0.5                                            GLM13190
  0066                CALL GAM                                                           GLM13200
```

```
 0067            PROB1 = Y                                                  GLM13210
 0068            ISAVE = STORE(I4) + 0.5                                    GLM13220
 0069            CALL GAM                                                   GLM13230
 0070            X = PROB1/(PROB1 + Y)                                      GLM13240
 0071            X = X*(STORE(I2) - STORE(I1)) + STORE(I1)                  GLM13250
 0072            GO TO 3366                                                 GLM13260
           C                                                                GLM13270
           C     CREATE A POISSON VARIATE                                   GLM13280
           C                                                                GLM13290
 0073       3266 ISAVE = 0                                                  GLM13300
 0074            Y = 1.0                                                    GLM13310
 0075       3277 CALL RANDOM                                                GLM13320
 0076            Y = X*Y                                                    GLM13330
 0077            IF(Y.LT.STORE(I3)) GO TO 3288                              GLM13340
 0078            ISAVE = ISAVE + 1                                          GLM13350
 0079            GO TO 3277                                                 GLM13360
 0080       3288 X = ISAVE                                                  GLM13370
 0081            GO TO 3366                                                 GLM13380
           C                                                                GLM13390
           C     CREATE A PASCAL VARIATE                                    GLM13400
           C                                                                GLM13410
 0082       3299 ISAVE = X                                                  GLM13420
 0083            X = ISAVE                                                  GLM13430
 0084            GO TO 3366                                                 GLM13440
           C                                                                GLM13450
           C     CREATE A BINOMIAL VARIATE                                  GLM13460
           C                                                                GLM13470
 0085       3300 ISAVE = 0                                                  GLM13480
 0086            M = STORE(I4) + 0.001                                      GLM13490
 0087            DO 3311 L=1,M                                              GLM13500
 0088            CALL RANDOM                                                GLM13510
 0089            IF(X.GT.STORE(I3)) GO TO 3311                              GLM13520
 0090            ISAVE = ISAVE + 1                                          GLM13530
 0091       3311 CONTINUE                                                   GLM13540
 0092            X = ISAVE                                                  GLM13550
 0093            GO TO 3366                                                 GLM13560
           C                                                                GLM13570
           C     CREATE A HYPERGEOMETRIC VARIATE                            GLM13580
           C                                                                GLM13590
 0094       3322 PROB1 = STORE(I3)                                          GLM13600
 0095            PROB2 = STORE(I4)                                          GLM13610
 0096            M = STORE(I+5) + 0.001                                     GLM13620
 0097            ISAVE = 0                                                  GLM13630
 0098            DO 3355 L=1,M                                              GLM13640
 0099            CALL RANDOM                                                GLM13650
 0100            IF(X.GT.PROB1) GO TO 3333                                  GLM13660
 0101            Y = 1.0                                                    GLM13670
 0102            ISAVE = ISAVE + 1                                          GLM13680
 0103            GO TO 3344                                                 GLM13690
 0104       3333 Y = 0.0                                                    GLM13700
 0105       3344 PROB1 = (PROB2*PROB1 - Y)/(PROB2 - 1.0)                    GLM13710
 0106       3355 PROB2 = PROB2 - 1.0                                        GLM13720
 0107            X = ISAVE                                                  GLM13730
```

```
             C                                                                   GLM13740
             C      PERFORM CHECKS                                               GLM13750
             C                                                                   GLM13760
 0108         3366 IF(X.LT.STORE(I1)) X = STORE(I1)                              GLM13770
 0109              IF(X.GT.STORE(I2)) X = STORE(I2)                              GLM13780
 0110         3377 RETURN                                                        GLM13790
 0111              END                                                           GLM13800
```

```
 0001          SUBROUTINE NORM                                                GLM13810
 0002         0COMMON CLOCK, SETUP, TNEXT, XNOW, YNOW, XTRAV, YTRAV, XTIME,YTIME,GLM13820
              1YCENTR, SMSTOP, TLOOK, CLAST, TSTART, TSTOP, X, Y, Z, INPT, IOUT, GLM13830
              2IPNH, IWF1, IWF2, IWF3, MAXBAY, MAXSTO, MAXKEY, MAXTYP, MAXEVT,   GLM13840
              3MAXQUE, MAXHET, IPS1, IPS2, IPS3, IPS4, IPS5, IPS6, IVENT, ISEED, GLM13850
              4IRROR, LOOK, ICOUNT, ISAVE, MATUNL, IPTBAY, ITOP, INVTAL, ITRAV,  GLM13860
              5JTRAV, WAIT, NWAIT, WMIN, WMAX, NGET, NCOUNT                      GLM13870
 0003          CALL RANDOM                                                    GLM13880
 0004          Y = X                                                          GLM13890
 0005          CALL RANDOM                                                    GLM13900
 0006          X = ((-2.0*ALOG(Y))**0.5)*(COS(6.283*X))                       GLM13910
 0007          RETURN                                                         GLM13920
 0008          END                                                            GLM13930
```

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 0001                SUBROUTINE GAM                                                    GLM13940
 0002               0COMMON CLOCK, SETUP, TNEXT, XNOW, YNOW, XTRAV, YTRAV, XTIME,YTIME,GLM13950
                    1YCENTR, SMSTOP, TLOOK, CLAST, TSTART, TSTOP, X, Y, Z, INPT, IOUT, GLM13960
                    2IPNH, IWF1, IWF2, IWF3, MAXBAY, MAXSTO, MAXKEY, MAXTYP, MAXEVT,   GLM13970
                    3MAXQUE, MAXHET, IPS1, IPS2, IPS3, IPS4, IPS5, IPS6, IVENT, ISEED, GLM13980
                    4IRROR, LOOK, ICOUNT, ISAVE, MATUNL, IPTBAY, ITOP, INVTAL, ITRAV,  GLM13990
                    5JTRAV, WAIT, NWAIT, WMIN, WMAX, NGET, NCOUNT                      GLM14000
 0003                Y = 0.0                                                           GLM14010
 0004                DO 3399 I=1,ISAVE                                                 GLM14020
 0005           3388 CALL RANDOM                                                       GLM14030
 0006                IF(X.LT.0.1E-77) GO TO 3388                                       GLM14040
 0007                X = ALOG(X)                                                       GLM14050
 0008           3399 Y = Y - X                                                         GLM14060
 0009                RETURN                                                            GLM14070
 0010                END                                                               GLM14080
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0001          SUBROUTINE PLOTTS                                                  GLM14090
0002         0COMMON CLOCK, SETUP, TNEXT, XNOW, YNOW, XTRAV, YTRAV, XTIME,YTIME,GLM14100
             1YCENTR, SMSTOP, TLOOK, CLAST, TSTART, TSTOP, X, Y, Z, INPT, IOUT, GLM14110
             2IPNH, IWF1, IWF2, IWF3, MAXBAY, MAXSTO, MAXKEY, MAXTYP, MAXEVT,   GLM14120
             3MAXQUE, MAXHET, IPS1, IPS2, IPS3, IPS4, IPS5, IPS6, IVENT, ISEED, GLM14130
             4IRROR, LOOK, ICOUNT, ISAVE, MATUNL, IPTBAY, ITOP, INVTAL, ITRAV,  GLM14140
             5JTRAV, WAIT, NWAIT, WMIN, WMAX, NGET, NCOUNT                      GLM14150
0003         0COMMON/STO/STORE( 300), KEY(50), ETIME(10), IBAYP(36,3), XBAY(36),GLM14160
             1YBAY(36), INVB(36,6), MXINVB(36), INVBT(36), IUSE(36), INVQ(3,20),GLM14170
             2INVQT(3),IPOOL(3),LEVELP(3),IFEED(3),IBTOP(3),NCHAR(3),NFEED(3),  GLM14180
             3MASK(3), XFEED(3), YFEED(3), XWORK(3), YWORK(3), MININV(3),       GLM14190
             4MAXINV(3), AVEINV(3), NTIME(10), STIME(10), SMIN(10), SMAX(10)    GLM14200
0004         0DIMENSION NOBS(42), MIN(42), MAX(42), AVE(42), STD(42), IPLOT(100)GLM14210
             1, SIDE(27), RFD(26), CFD(26), ABSA(15), LINEP(25), LINEC(50),     GLM14220
             2ID1(7), ID2(7), ID3(7), ID4(7)                                    GLM14230
0005          DATA ABSA/.05,.1,.15,.2,.25,.1,.2,.3,.4,.5,.6,.7,.8,.9,1.0/       GLM14240
0006         0DATA IBLK,IPLUS,ID1,ID2,ID3,ID4/1H ,1H+,4HTRAV,4HIDLE,4HPICK,     GLM14250
             14HSET ,4HSQUA,4HSWIN,4HBREA,4HELIN,4H-FRE,4H BIL,4HBILL,4HRE B,   GLM14260
             24HG BI,4HK TI,4HG   ,4HE TI,4HLETS,4HETS ,4HILLE,4HLLET,4HMES ,   GLM14270
             34H    ,4HME  ,4H UP ,4HDOWN,4HTS  ,4HS   ,4H    /                 GLM14280
        C                                                                        GLM14290
        C     THIS SUBROUTINE DEVELOPS PLOTS AND HISTOGRAMS, FIRST, IF THERE IS GLM14300
        C        ANY BAY DATA TO PRINT, PRINT IT                                 GLM14310
        C                                                                        GLM14320
        C     NOTE---THE FIRST 5 VARIABLES IN THE DIMENSION STATEMENT MUST BE   GLM14330
        C            ASSIGNED THE SAME VALUE AS THE CHECK VARIABLE NUMB WHICH   GLM14340
        C            IS USED IN THE FOLLOWING MNEMONIC DIMENSIONING SCHEME.     GLM14350
        C                                                                        GLM14360
        C    0DIMENSION NOBS(NUMB), MIN(NUMB), MAX(NUMB), AVE(NUMB), STD(NUMB), GLM14370
        C    1IPLOT(100),SIDE(27),RFD(26),CFD(26),ABSA(15),LINEP(25),LINEC(50)  GLM14380
        C                                                                        GLM14390
0007          NUMB = MAXBAY + 2*MAXTYP                                           GLM14400
0008          IF(ICOUNT.EQ.0) GO TO 3544                                         GLM14410
        C                                                                        GLM14420
        C     LIST THE BAY DATA                                                  GLM14430
        C                                                                        GLM14440
0009          IF(IPS2.NE.0) GO TO 3444                                           GLM14450
0010          IPAGE = 1                                                          GLM14460
0011          LINE  = 999                                                        GLM14470
0012          REWIND IWF2                                                        GLM14480
0013          DO 3422 I=1,ICOUNT                                                 GLM14490
0014          IF(LINE.LT.50) GO TO 3411                                          GLM14500
0015          WRITE (IOUT,3400) IPAGE, (J, J=1,MAXBAY)                           GLM14510
0016     34000FORMAT (1H1, 54X, 9HBAY TRACE, 55X, 6HPAGE =, I4/ 5HOREF., 40X,   GLM14520
             111HBAY NUMBERS/ 4H NO., 3X, 40I3)                                 GLM14530
0017          IPAGE = IPAGE + 1                                                  GLM14540
0018          LINE = 0                                                           GLM14550
0019     3411 LINE = LINE + 1                                                    GLM14560
0020          READ (IWF2) (NOBS(J),J=1,MAXBAY),(AVE(J),J=1,14),(MIN(J),J=1,12)  GLM14570
0021     3422 WRITE (IOUT,3433) I, (NOBS(J), J=1,MAXBAY)                         GLM14580
0022     3433 FORMAT (1H , I5, 1X, 40I3)                                         GLM14590
        C                                                                        GLM14600
        C     LIST THE TIME DATA                                                 GLM14610
```

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                C
0023             3444 IF(IPS3.NE.0) GO TO 3499
0024                  IPAGE = 1
0025                  LINE  = 999
0026                  REWIND IWF2
0027                  DO 3477 I=1,ICOUNT
0028                  IF(LINE.LT.50) GO TO 3466
0029                  WRITE (IOUT,3455) IPAGE
0030             34550FORMAT (1H1, 54X, 9HTIME DATA, 55X, 6HPAGE =, I4/ 5HOREF., 6X,
                     16HTRAVEL, 8X, 9HIDLE-FREE, 2X, 15HPICK UP BILLETS, 1X, 14HSET DOWN
                     2 BILL., 1X, 14HSQUARE BILLETS, 2X, 13HSWING BILLETS, 5X, 6HBREAKS/
                     34H NO., 2X, 7(2X,3HNO.,6X,4HTIME))
0031                  IPAGE = IPAGE + 1
0032                  LINE = 0
0033             3466 LINE = LINE + 1
0034                  READ (IWF2) (NOBS(J),J=1,MAXBAY),(AVE(J),J=1,14),(MIN(J),J=1,12)
0035             3477 WRITE (IOUT,3488) I, (MIN(J), AVE(J), J=1,7)
0036             3488 FORMAT (1H , I5, 7(I5,F10.2))
                C
                C     LIST THE TRAVEL DATA
                C
0037             3499 IF(IPS4.NE.0) GO TO 3544
0038                  IPAGE = 1
0039                  LINE  = 999
0040                  REWIND IWF2
0041                  DO 3522 I=1,ICOUNT
0042                  IF(LINE.LT.50) GO TO 3511
0043                  WRITE (IOUT,3500) IPAGE, (J, J=1,MAXTYP)
0044             35000FORMAT (1H1, 47X, 24HDISTANCE AND FEEDER DATA, 47X, 6HPAGE =, I4/
                     15HOREF., 4X, 6(1H-), 1X, 11HX DIRECTION, 1X, 6(1H-), 5X, 6(1H-),
                     21X, 11HY DIRECTION, 1X, 6(1H-),10X, 32HFEEDER CALLS AND TOTAL WAIT
                     3 TIME/ 4H NO.,5X,2(2X,3HNO.,2X,8HDISTANCE,6X,4HTIME,5X),I12,2I15)
0045                  IPAGE = IPAGE + 1
0046                  LINE = 0
0047             3511 LINE = LINE + 1
0048                  READ (IWF2) (NOBS(J),J=1,MAXBAY),(AVE(J),J=1,14),(MIN(J),J=1,12)
0049             35220WRITE (IOUT,3533) I, MIN(11), AVE(11), AVE(13), MIN(12), AVE(12),
                     1AVE(14), (MIN(J), AVE(J), J=8,10)
0050             3533 FORMAT (1H ,I5,I8,F10.0,F10.2,I10,F10.0,F10.2,2X,3(I5,F10.2))
                C
                C     LIST THE VITAL RUN STATISTICS
                C
0051             3544 WRITE (IOUT,3555) CLOCK
0052             35550FORMAT (1H1,20X,67HTRAVEL RESULTS---DISTANCE IN FEET---TOTAL ELAPS
                     1ED TIME IN MINUTES =,F10.2/ 1H0,56X,24HX DIRECTION  Y DIRECTION)
0053                  DO 3566 I=1,6
0054             3566 AVE(I) = 0.0
0055                  IF(ITRAV.NE.0) AVE(1) = XTRAV/FLOAT(ITRAV)
0056                  IF(JTRAV.NE.0) AVE(2) = YTRAV/FLOAT(JTRAV)
0057                  IF(ITRAV.NE.0) AVE(3) = XTIME/FLOAT(ITRAV)
0058                  IF(JTRAV.NE.0) AVE(4) = YTIME/FLOAT(JTRAV)
0059                  IF(XTIME.NE.0.0) AVE(5) = XTRAV/XTIME
0060                  IF(YTIME.NE.0.0) AVE(6) = YTRAV/YTIME
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 0061          0WRITE (IOUT,3577) ITRAV, JTRAV, XTRAV, YTRAV, AVE(1), AVE(2),     GLM15150
                1XTIME, YTIME, AVE(3), AVE(4), AVE(5), AVE(6)                      GLM15160
 0062      35770FORMAT (32H NUMBER OF TIMES TRAVEL OCCURRED, 23(1H-), 2I13/ 24H TOGLM15170
                1TAL DISTANCE TRAVELED, 31(1H-), 2F13.2/ 25H AVERAGE LENGTH OF TRAVGLM15180
                2EL, 30(1H-), 2F13.2/ 21H TOTAL TIME OF TRAVEL, 34(1H-), 2F13.2/   GLM15190
                323H AVERAGE TIME OF TRAVEL, 32(1H-), 2F13.2/ 24H AVERAGE SPEED OF GLM15200
                4TRAVEL, 31(1H-), 2F13.2)                                          GLM15210
 0063            WRITE (IOUT,3588)                                                 GLM15220
 0064      35880FORMAT (1H0, 20X, 58HPORTION OF TIME THE CRANE SPENT ON ITS ARRAY GLM15230
                1OF ACTIVITIES/ 1H0, 2X, 8HACTIVITY, 6X, 27HNO. TIMES ACTIVITY OCCUGLM15240
                2RRED, 2X, 16HTOTAL TIME SPENT, 8X, 8HAVE TIME, 8X, 8HMIN TIME, 8X,GLM15250
                38HMAX TIME, 3X, 17H0/0 OF TOTAL TIME)                             GLM15260
 0065            DO 3599 I=1,7                                                     GLM15270
 0066            X = 0.0                                                           GLM15280
 0067            Y = 0.0                                                           GLM15290
 0068            IF(NTIME(I).NE.0) X = STIME(I)/FLOAT(NTIME(I))                    GLM15300
 0069            IF(CLOCK.NE.0.0) Y = (100.0*STIME(I))/CLOCK                       GLM15310
 0070      35990WRITE (IOUT,3600) ID1(I), ID2(I), ID3(I), ID4(I), NTIME(I),        GLM15320
                1STIME(I), X, SMIN(I), SMAX(I), Y                                  GLM15330
 0071      3600 FORMAT (1H , 4A4, I20, F25.2, 5F16.2)                              GLM15340
          C                                                                        GLM15350
          C      LIST WAIT TIME AND FEEDER STATISTICS                              GLM15360
          C                                                                        GLM15370
 0072            X = WAIT/FLOAT(NWAIT)                                             GLM15380
 0073            WRITE (IOUT,3611) NWAIT, WAIT, X, WMIN, WMAX, NGET                GLM15390
 0074      36110FORMAT (1H0, 20X, 60HAMOUNT OF TIME INDEPENDENT EVENTS HAD TO WAITGLM15400
                1 FOR PROCESSING/ 28H NO TIMES WAITING OCCURRED =, I6, 3X, 7HTOTAL GLM15410
                2=, F12.2, 3X, 5HAVE =, F6.2, 3X, 5HMIN =, F6.2, 3X, 5HMAX =, F6.2/GLM15420
                382H0NO OF TIMES A FEEDER HAD TO WAIT FOR THE HAULING OF BILLETS PRGLM15430
                4IOR TO LOADING IT =, I6/ 1H0, 20X, 50HFEED TABLE REVIEW (NOTE FOLLGLM15440
                5OW ON HISTOGRAMS ALSO)/ 11H FEED TABLE, 4X, 20HNO OF TIMES SERVICEGLM15450
                6D, 3X, 15HTOTAL WAIT TIME, 3X, 13HAVE WAIT TIME, 3X, 13HMIN WAIT TGLM15460
                7IME, 3X, 13HMAX WAIT TIME)                                        GLM15470
 0075            DO 3622 I=8,10                                                    GLM15480
 0076            J = I - 7                                                         GLM15490
 0077            AVE(J) = 0.0                                                      GLM15500
 0078            IF(NTIME(I).NE.0) AVE(J) = STIME(I)/FLOAT(NTIME(I))               GLM15510
 0079      3622 WRITE (IOUT,3633) J, NTIME(I), STIME(I), AVE(J), SMIN(I), SMAX(I)  GLM15520
 0080      3633 FORMAT (1H , I8, I20, F24.2, 3F16.2)                               GLM15530
          C                                                                        GLM15540
          C      LIST INVENTORY STATISTICS                                         GLM15550
          C                                                                        GLM15560
 0081            DO 3644 I=1,MAXTYP                                                GLM15570
 0082      3644 MIN(I) = AVEINV(I)/FLOAT(INVTAL) + 0.5                             GLM15580
 0083            WRITE (IOUT,3655) INVTAL,MININV,MAXINV,(MIN(I), I=1,3),MASK,INVQT GLM15590
 0084      36550FORMAT (1H0, 20X, 26HINVENTORY REVIEW (BILLETS)/ 16H TOTAL INVENTOGLM15600
                1RY, 5X, 5H5 1/4, 9X, 1H6, 5X, 16H7 3/8 - NO OBS =, I10/ 1H , 12X, GLM15610
                23HMIN, 3I10/ 1H , 12X, 3HMAX, 3I10/ 1H , 12X, 3HAVE, 3I10/ 1H ,   GLM15620
                312X, 3HEND, 3I10/ 16H0CAR QUES AT END, 3I10/ 1H0, 4(28H BAY END INGLM15630
                4V NO USES 0/0 USE,2X))                                            GLM15640
 0085            K = 0                                                             GLM15650
 0086            DO 3666 I=1,MAXBAY                                                GLM15660
 0087      3666 K = K + IUSE(I)                                                    GLM15670
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0088          DO 3677 I=1,NUMB                                          GLM15680
0089          NOBS(I)= 0                                                GLM15690
0090          MIN(I) = 0                                                GLM15700
0091          MAX(I) = 0                                                GLM15710
0092          STD(I) = 0.0                                              GLM15720
0093          IF(I.GT.MAXBAY) GO TO 3677                                GLM15730
0094          NOBS(I)= I                                                GLM15740
0095          MIN(I) = INVBT(I)                                         GLM15750
0096          MAX(I) = IUSE(I)                                          GLM15760
0097          STD(I) = 100.0*(FLOAT(IUSE(I))/FLOAT(K))                  GLM15770
0098     3677 CONTINUE                                                  GLM15780
0099          ISAVE = FLOAT(MAXBAY)/4.0 + 0.999                         GLM15790
0100          DO 3688 I=1,ISAVE                                         GLM15800
0101          J = I + ISAVE                                             GLM15810
0102          K = I + ISAVE*2                                           GLM15820
0103          L = I + ISAVE*3                                           GLM15830
0104     36880WRITE (IOUT,3699) NOBS(I), MIN(I), MAX(I), STD(I), NOBS(J),  GLM15840
             1MIN(J), MAX(J), STD(J), NOBS(K), MIN(K), MAX(K), STD(K), NOBS(L), GLM15850
             2MIN(L), MAX(L), STD(L)                                    GLM15860
0105     3699 FORMAT (1H , 4(I3,1H.,2I8,F8.3,2X))                       GLM15870
         C                                                              GLM15880
         C    PUNCH CONTINUATION CARDS FOR FUTURE RUNS - CONTROL AND BAY CARDS  GLM15890
         C       FIRST - REDUCE FUTURE EVENT TIMES BY THE CURRENT CLOCK READING GLM15900
         C                                                              GLM15910
0106          DO 3700 I=1,MAXEVT                                        GLM15920
0107     3700 ETIME(I) = ETIME(I) - SMSTOP                              GLM15930
0108         0WRITE (IPNH,3711) XNOW, YNOW, ISEED, MATUNL, IPTBAY, ITOP, IFEED, GLM15940
             1IBTOP, LEVELP, NCHAR, NFEED, (XFEED(I), YFEED(I), I=1,MAXTYP),  GLM15950
             2(XWORK(I), YWORK(I), I=1,MAXTYP), ((INVQ(I,J), J=1,MAXQUE),     GLM15960
             3I=1,MAXTYP), (ETIME(I), I=1,MAXEVT)                       GLM15970
0109     3711 FORMAT (26X, 2F4.0, I10, 18I2/ 12F6.1/ 20I4/ 20I4/ 20I4/ 10F8.2)  GLM15980
0110          DO 3722 I=1,MAXBAY                                        GLM15990
0111     37220WRITE (IPNH,3733) I, (IBAYP(I,J), J=1,MAXTYP), XBAY(I), YBAY(I),  GLM16000
             1MXINVB(I), (INVB(I,J), J=1,MAXHET)                        GLM16010
0112     3733 FORMAT (4I2, 2F6.1, 11I5)                                 GLM16020
         C                                                              GLM16030
         C    CONSTRUCT HISTOGRAMS OF THE WAIT TIME EXPERIENCED BY EACH FEEDER  GLM16040
         C                                                              GLM16050
0113          DO 3877 I=1, MAXTYP                                       GLM16060
0114          WRITE (IOUT,3744) I                                       GLM16070
0115     3744 FORMAT (1H1, 20X, 27HWAIT TIME OF FEED TABLE NO., I3)     GLM16080
0116          REWIND IWF3                                               GLM16090
0117          STD(I) = 0.0                                              GLM16100
0118          M = I + 7                                                 GLM16110
0119          SIDE(1) = SMIN(M)                                         GLM16120
0120          SIDE(27)= SMAX(M)                                         GLM16130
0121          X = (SIDE(27) - SIDE(1))/26.0                             GLM16140
0122          DO 3755 J=1,25                                            GLM16150
0123     3755 SIDE(J+1) = SIDE(J) + X                                   GLM16160
0124          DO 3766 J=1,26                                            GLM16170
0125     3766 RFD(J) = 0.0                                              GLM16180
0126          DO 3799 J=1,NCOUNT                                        GLM16190
0127          READ (IWF3) N, X                                          GLM16200
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          IF(N.NE.M) GO TO 3799                                           GLM16210
          Y = AVE(I) - X                                                  GLM16220
          STD(I) = STD(I) + Y*Y                                           GLM16230
          DO 3777 K=2,26                                                  GLM16240
          L = K - 1                                                       GLM16250
          IF(X.LT.SIDE(K)) GO TO 3788                                     GLM16260
     3777 CONTINUE                                                        GLM16270
          L = 26                                                          GLM16280
     3788 RFD(L) = RFD(L) + 1.0                                           GLM16290
     3799 CONTINUE                                                        GLM16300
          DO 3800 J=1,26                                                  GLM16310
          RFD(J) = RFD(J)/FLOAT(NTIME(M))                                 GLM16320
          CFD(J) = RFD(J)                                                 GLM16330
     3800 IF(J.GT.1) CFD(J) = CFD(J) + CFD(J-1)                           GLM16340
C                                                                         GLM16350
C         PRINT THE HISTOGRAM                                             GLM16360
C                                                                         GLM16370
          WRITE (IOUT,3811) ABSA, SIDE(1), SIDE(1)                        GLM16380
     38110FORMAT (1H0, I8X, 4HRFD , 5F5.2, 21X, 4HCFD , 10(F4.1, 1X)/ 1H , GLM16390
         1F18.4, 2H I, 5(5H----I), 4H MIN, F19.4, 2H I, 10(5H----I), 4H MIN)GLM16400
          DO 3866 J=1,26                                                  GLM16410
          DO 3822 K=1,25                                                  GLM16420
          LINEP(K) = IBLK                                                 GLM16430
          X = FLOAT(K)/100.0                                              GLM16440
     3822 IF(X.LE.RFD(J)) LINEP(K) = IPLUS                                GLM16450
          DO 3833 K=2,100,2                                               GLM16460
          L = K/2                                                         GLM16470
          LINEC(L) = IBLK                                                 GLM16480
          X = FLOAT(K)/100.0 - 0.01                                       GLM16490
     3833 IF(X.LE.CFD(J)) LINEC(L) = IPLUS                                GLM16500
     38440WRITE (IOUT,3855) LINEP,RFD(J),LINEC,CFD(J),SIDE(J+1),SIDE(J+1) GLM16510
     38550FORMAT (1H , 18X, 2H I, 25A1, F5.3, 18X, 2H I, 50A1, F5.3/ 1H , GLM16520
         12(F18.4, 2H I, 30X))                                            GLM16530
     3866 CONTINUE                                                        GLM16540
          X = NTIME(M) - 1                                                GLM16550
          STD(I) = SQRT(STD(I)/X)                                         GLM16560
     3877 WRITE (IOUT,3888) STD(I)                                        GLM16570
     3888 FORMAT (1H+, 45X, 4H MAX, 72X, 4H MAX/ 10H0STD DEV =, F10.2)    GLM16580
          IF(IPS6.NE.0) RETURN                                            GLM16590
C                                                                         GLM16600
C         COMPUTE MIN, MAX, AVE, STD                                      GLM16610
C                                                                         GLM16620
          DO 3899 I=1,NUMB                                                GLM16630
          MIN(I) = 999999                                                 GLM16640
          MAX(I) =-999999                                                 GLM16650
          AVE(I) = 0.0                                                    GLM16660
     3899 STD(I) = 0.0                                                    GLM16670
          REWIND IWF1                                                     GLM16680
          DO 3911 I=1,LOOK                                                GLM16690
          READ (IWF1) CLOCK, NOBS                                         GLM16700
          DO 3900 J=1,NUMB                                                GLM16710
          IF(NOBS(J).LT.MIN(J)) MIN(J) = NOBS(J)                          GLM16720
          IF(NOBS(J).GT.MAX(J)) MAX(J) = NOBS(J)                          GLM16730
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 0173          3900 AVE(J) = AVE(J) + NOBS(J)                                       GLM16740
 0174          3911 CONTINUE                                                        GLM16750
 0175               DO 3922 J=1,NUMB                                                GLM16760
 0176          3922 AVE(J) = AVE(J)/FLOAT(LOOK)                                     GLM16770
 0177               REWIND IWF1                                                     GLM16780
 0178               DO 3944 I=1,LOOK                                                GLM16790
 0179               READ (IWF1) CLOCK, NOBS                                         GLM16800
 0180               DO 3933 J=1,NUMB                                                GLM16810
 0181               X = FLOAT(NOBS(J)) - AVE(J)                                     GLM16820
 0182               X = X*X                                                         GLM16830
 0183          3933 STD(J) = STD(J) + X                                             GLM16840
 0184          3944 CONTINUE                                                        GLM16850
 0185               X = LOOK - 1                                                    GLM16860
 0186               IF(X.LE.0.0) GO TO 3999                                         GLM16870
 0187               DO 3955 J=1,NUMB                                                GLM16880
 0188          3955 STD(J) = SQRT(STD(J)/X)                                         GLM16890
               C                                                                    GLM16900
               C    LIST STATISTICS FOR SNAPSHOT INTERVALS                          GLM16910
               C                                                                    GLM16920
 0189               WRITE (IOUT,3966) LOOK                                          GLM16930
 0190          39660FORMAT (1H1, 10X, 38HSTATISTICS FOR ITEMS LISTED - NO OBS =, I6/ GLM16940
                   18HOITEM NO, 9X, 3HMIN, 9X, 3HMAX, 9X, 3HAVE, 5X, 7HSTD DEV)    GLM16950
 0191               DO 3977 I=1,NUMB                                                GLM16960
 0192          3977 WRITE (IOUT,3988) I, MIN(I), MAX(I), AVE(I), STD(I)             GLM16970
 0193          3988 FORMAT (1H , I6, 1H., 2I12, 2F12.2)                             GLM16980
               C                                                                    GLM16990
               C    PLOT BAY STOCK LEVEL                                            GLM17000
               C                                                                    GLM17010
 0194          3999 DO 4044 I=1,MAXBAY                                              GLM17020
 0195               IF(MAX(I).EQ.MIN(I)) GO TO 4044                                 GLM17030
 0196               REWIND IWF1                                                     GLM17040
 0197               LAST = -99999                                                   GLM17050
 0198               X = MXINVB(I)                                                   GLM17060
 0199               WRITE (IOUT,4000) I                                             GLM17070
 0200          4000 FORMAT (1H0, 10X, 28HSTOCK LEVEL (BILLETS) OF BAY, I3)          GLM17080
 0201               DO 4033 J=1,LOOK                                                GLM17090
 0202               READ (IWF1) CLOCK, NOBS                                         GLM17100
 0203               IF(LAST.EQ.NOBS(I)) GO TO 4033                                  GLM17110
 0204               LAST = NOBS(I)                                                  GLM17120
 0205               K = 99.0*(1.0 - (X - FLOAT(NOBS(I)))/X) + 1.5                   GLM17130
 0206               DO 4011 L=1,100                                                 GLM17140
 0207          4011 IPLOT(L) = IBLK                                                 GLM17150
 0208               IPLOT(K) = IPLUS                                                GLM17160
 0209               WRITE (IOUT,4022) J, CLOCK, IPLOT, NOBS(I)                      GLM17170
 0210          4022 FORMAT (1H , I5, F12.2, 1H*, 100A1, 1H*, I6)                    GLM17180
 0211          4033 CONTINUE                                                        GLM17190
 0212          4044 CONTINUE                                                        GLM17200
               C                                                                    GLM17210
               C    PLOT MATERIAL IN CARS QUES                                      GLM17220
               C                                                                    GLM17230
 0213               LOW = MAXBAY + 1                                                GLM17240
 0214               IUP = MAXBAY + MAXTYP                                           GLM17250
 0215               DO 4088 I=LOW,IUP                                               GLM17260
```

```
      REWIND IWF1
      LAST = -99999
      WRITE (IOUT,4055) I
 4055 FORMAT (1H0, 10X, 24HCAR QUE PLOT OF MATERIAL, I5)
      IRAN = MAX(I) - MIN(I)
      DO 4077 J=1,LOOK
      READ (IWF1) CLOCK, NOBS
      IF(LAST.EQ.NOBS(I)) GO TO 4077
      LAST = NOBS(I)
      K = 99.0*(1.0 - (FLOAT(MAX(I) - NOBS(I))/FLOAT(IRAN))) + 1.5
      DO 4066 L=1,100
 4066 IPLOT(L) = IBLK
      IPLOT(K) = IPLUS
      WRITE (IOUT,4022) J, CLOCK, IPLOT, NOBS(I)
 4077 CONTINUE
 4088 CONTINUE
C
C     CONSTRUCT HISTOGRAMS OF THE WORK POOL
C
      LOW = LOW + MAXTYP
      IUP = IUP + MAXTYP
      DO 4200 I=LOW,IUP
      WRITE (IOUT,4099) I
 4099 FORMAT (1H1, 20X, 13HWORK POOL NO., I3)
      REWIND IWF1
      SIDE(1) = MIN(I)
      SIDE(27)= MAX(I)
      X = (SIDE(27) - SIDE(1))/26.0
      DO 4100 J=1,25
 4100 SIDE(J+1) = SIDE(J) + X
      DO 4111 J=1,26
 4111 RFD(J) = 0.0
      DO 4144 J=1,LOOK
      READ (IWF1) CLOCK, NOBS
      X = NOBS(I)
      DO 4122 K=2,26
      L = K - 1
      IF(X.LT.SIDE(K)) GO TO 4133
 4122 CONTINUE
      L = 26
 4133 RFD(L) = RFD(L) + 1.0
 4144 CONTINUE
      DO 4155 J=1,26
      RFD(J) = RFD(J)/FLOAT(LOOK)
      CFD(J) = RFD(J)
 4155 IF(J.GT.1) CFD(J) = CFD(J) + CFD(J-1)
C
C     PRINT THE HISTOGRAM
C
      WRITE (IOUT,3811) ABSA, SIDE(1), SIDE(1)
      DO 4199 J=1,26
      DO 4166 K=1,25
      LINEP(K) = IBLK
```

```
      X = FLOAT(K)/100.0                                                GLM17800
 4166 IF(X.LE.RFD(J)) LINEP(K) = IPLUS                                  GLM17810
      DO 4177 K=2,100,2                                                 GLM17820
      L = K/2                                                           GLM17830
      LINEC(L) = IBLK                                                   GLM17840
      X = FLOAT(K)/100.0 - 0.01                                         GLM17850
 4177 IF(X.LE.CFD(J)) LINEC(L) = IPLUS                                  GLM17860
41880WRITE (IOUT,3855) LINEP,RFD(J),LINEC,CFD(J),SIDE(J+1),SIDE(J+1)    GLM17870
 4199 CONTINUE                                                          GLM17880
 4200 WRITE (IOUT,4211)                                                 GLM17890
 4211 FORMAT (1H+, 45X, 4H MAX, 72X, 4H MAX)                            GLM17900
      RETURN                                                            GLM17910
      END                                                               GLM17920
```

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APPENDIX E

LETTER OF REQUEST FOR THE STUDY

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DEPARTMENT OF THE ARMY
SCRANTON ARMY AMMUNITION PLANT
SCRANTON, PENNSYLVANIA 18501

IN REPLY REFER TO:
SARSC - C

19 December 1975

SUBJECT: Billet Yard Crane

Commander
US Army Armament Command
ATTN: AMSAR-SA
Rock Island, IL 61201

1. Reference is made to the visit of Mr. Jerry Moeller to Scranton AAP relative to preparing a mathematical model of the Billet Yard Crane operation.

2. Subsequent to reference visit and further discussions thereof, this letter formalizes our request for support.

3. It is understood that a mathematical model can be structured but that additional operational data is required for satisfactory input. Your office is requested to provide the model. When adequate data is collected, a further review of action will be made.

4. Your assistance in this matter is greatly appreciated.

Daniel K. Malone
DANIEL K. MALONE
LTC, OrdC
Commanding

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